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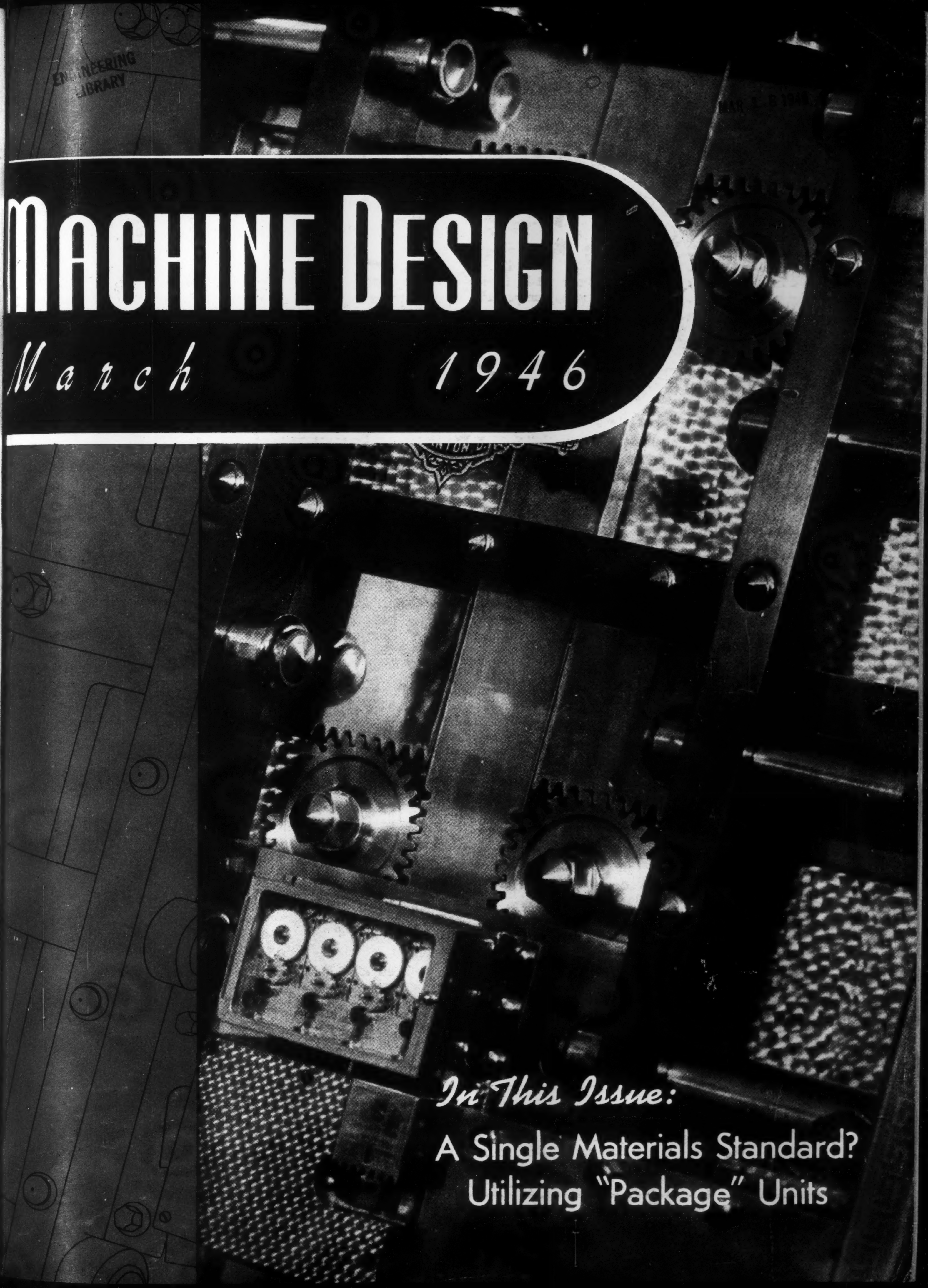
MACHINE DESIGN

March 1946



In This Issue:

A Single Materials Standard?
Utilizing "Package" Units

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SPECIFICATIONS

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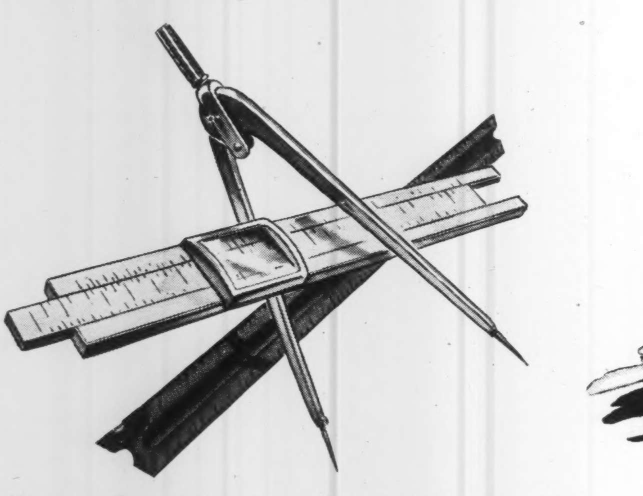

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Published by The Penton Publishing Co. E. L. Shaner, Pres. and Treas.; G. O. Hays, Vice Pres. and Gen. Mgr.; R. C. Jaenke, Vice Pres.; F. G. Steinebach, Vice Pres. and Secy.; E. L. Werner, Asst. Treas. Published on seventh of month.

Subscription in U.S. and possessions, Canada, Cuba, Mexico, Central and South America: Two years, $10; one year, $6. Single copies, 50 cents. Other countries: Two years, $14; one year, $8.

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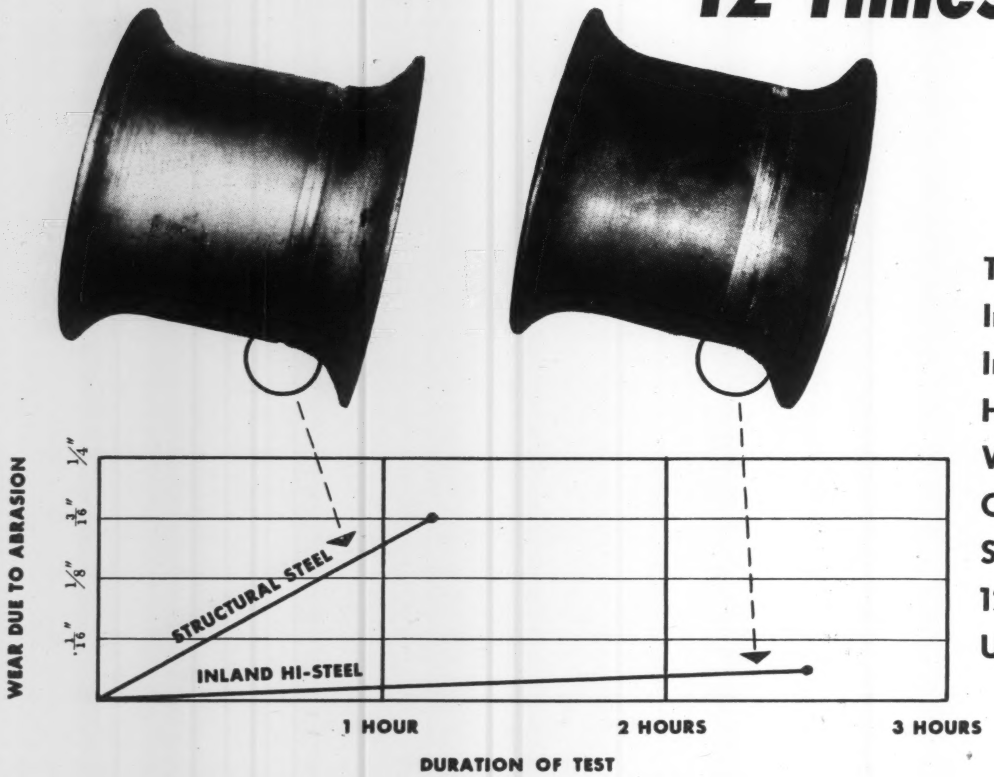

Tests Show That Inland HI-STEEL,* In the Precipitation Hardened Condition, Will Outwear Ordinary Structural Steel More Than 12 Times When Used For Winch Heads

*TRADEMARK—REG. U. S. PAT. OFF.

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INLAND HI-STEEL

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Classified for Convenience when Studying Specific Design Problems

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MACHINE DESIGN

Should a Single Materials Specification System Be Established?

A Timely Symposium

WILL the varied materials specification systems of today promote increased efficiency, or increased confusion, during the vital years of further industrial expansion that lie ahead? This is a question of primary importance to every engineer in the country.

Before it can be answered competently, many influencing factors, which in themselves take the form of questions, must be given serious consideration. Among these are: Should an *overall* engineering society board be organized for co-ordination of materials specification methods as well as for initiating and promoting other standardization work? Should a Government agency head up such activity? Do requirements peculiar to the various industries differ to such a degree that it would be inadvisable to reduce the number of specification systems?

To help clarify this inherently controversial matter, and to aid in crystallizing ideas pertaining to it, MACHINE DESIGN has thrown open its pages for discussion by competent engineers representative of the machine-building field. The considered opinions of a number of these engineers are presented on the following pages.

. . . definite need . . . not under Government control

By George H. Harnden
Head of Spec. and Tech. Data Sect. of Wks. Lab.
General Electric Co., Schenectady, N. Y.

With the growing interest in material standards by all branches of industry it becomes very necessary that there be established a single system of material specifications. World War II focused attention on the nonuniformity existing in the materials specification field. Manufacturers of equipment for the armed forces were forced to work to as many as six or more different specifications covering the same raw material, depending upon the bureau from which the contract emanated. Many specifications were prepared in close cooperation with the manufacturers of the raw materials, while the emergency situation required the immediate issuance of others which were based on the best published information or on first-hand test data, with questions being asked later. This led to many differences in specifications for the same material, some of major importance, others of a minor nature, all of which, however, were an annoyance to an apparatus or machine manufacturer in trying to employ standard or commercial materials to expedite manufacture.

Many companies have their own specification-writing groups. Specifications on raw materials emanating from such groups generally are based on commercially standard materials of industry, insofar as the engineering design of the apparatus for which it is used will allow. These specifications are prepared, generally, with the assistance of the manufacturers of the raw material after a study is made of existing specifications on the same subject. A single materials specification system would materially aid such specification-writing groups.

Many associations and societies, such as engineering, manufacturers, etc., prepare specifications. Usually, in each case, they look no farther than their own particular need and the result is another specification on the same material. No attempt is made in most cases to co-ordinate this work with that of other groups working with identical materials on similar problems.

There is a definite need for further standardization insofar as this is practical. It must, however, be on a voluntary and co-operative basis; co-operative not only from the standpoint of the manufacturers of the materials in question, but also on the part of the users, the various engineering societies, and the manufacturers associations. Each must become imbued with the spirit of give and take. They must put aside their so called "prerogatives" and be prepared to work together with an open mind. This means that manufacturers of materials must be willing to get together with specification-writing groups and give all the necessary information on their respective products necessary for an engineering standard. This would not require manufacturers to divulge information on the "know how" or that "inherent quality" which each puts into his product and is his stock in trade. It would mean that engineering societies, manufacturers associations and similar groups be prepared to exchange engineering information, test data, and drafts of proposed material specifications so that they could be co-ordinated. It would mean that consumers make every effort to use standardized materials by proper educational programs among their engineering divisions, the setting up of proper internal standards, participation in standardizing societies and programs, and frequent round-table discussions with the manufacturers of the various materials .

This standardization should take the form of standard specifications on raw materials of all kinds, types, grades, etc., standard procedures or methods of test for determining properties of materials in accordance with the specifications, standard dimensions, sizes, threads, colors, etc., and standards on commercial sizes available, preferably on the basis of the preferred-numbers system.

This work should not be centered around nor undertaken by any of the specifications committees of the various government bureaus, including the National Bureau of Standards, or by any other existing or planned government agency. Obviously, government bureaus should be

Fig. 1—Is there actually a need for the many different specifications which cover identical or closely similar materials, as shown below? This reproduced chart is but a small portion of the Cross-Index of Chemically Equivalent Specifications published and distributed by the General Motors corporation

de ber	Specification	Material & Form	Source	Copper Min-Max	Zinc Min-Max	Tin Min-Max	Lead Min-Max	Antimony Min-Max	Iron Min-Max	Phosphorus Min-Max	Min-Max	Min-Max	
065	57-172-1D	Sheet & Strip	A	68.5-71.5	Rem.		.07		.05		(.006 Bi.,.	0001Hg.,.15	Other
	47B4	" " "	N	"	"		"		"		" "	" " "	"
	JAN-B-50	" " "	J	"	"		"		"		" "	" " "	"
	O.S.1331	" " "	N	"	"		"		"		" "	" " "	"
	SAE-70, Gr. A	" " "	S	"	"		05		"				
	B36-44T, Alloy 6	" " "	T	"	"		"		"				
	B19-44T	" " "	T	"	"		.07		"		(Cu.+Zn.-99.	85 Min.)	
	AMS-4505A	" " "	M	"	"		.05		"				
	57-173C	Cart. Brass	A	"	"		.07		"				.15 T
	B129-44T	Cart. Cups	T	"	"		"		"		(Cu.+Zn.-99.	85 Min.)	
	57-172-2C	" "	A		(Analysis Covered by 57-172-1D)								
	O.S.1051	Cart. Disks	N	68.0-71.0	Rem.		.07		.05				.15 T
	QQ-B-611a, Comp.E	Wrought Alloy	F	68.5-71.5	"		"		.04				
	SAE-74, Alloy C	Tubing	S	"	"		.10		.07				
	B135-43T, Alloy 2	"	T	"	"		.075		.06				
	B14-18	Tubes - Boiler	T	69.0	"		.50		.10				.50 T
	AMS-4555	Tubing	M	65.0-71.5	"	.15	.80		.08				
	QQ-W-321, Gr. C	Wire	F	69.0-74.0	"		.075		.06				
	B134-44T, Alloy 6	"	T	68.5-71.5	"		.07		.05				
	QQ-S-551, Comp. C	Solder	F	68.0-72.0	"	None	.30		.10				
	46S15a, Gr. C	"	N	"	"		"		"				

represented but should not control this work; otherwise the freedom and flexibility would be lost. It should be kept on a voluntary basis, and in the hands of an unbiased, free-thinking and well-balanced group of representatives of the consumer and manufacturing industries, as well as the engineering societies and the manufacturers associations.

. . . makes sense, with superimposed requirements

By H. W. Gillett

Technical Adviser
Battelle Memorial Inst., Columbus

IT IS neither practical nor desirable to have but one set of detailed specifications. In steels, for example, the automotive engineers found it worthwhile to pay for closer limits on carbon than are practical in a general specification, in order to simplify heat treatment for continuous rather than batch operation.

In the present period of transition from specifications for composition to those for properties, it is difficult to set up a single specification without yielding to the temptation to include both; whereas, a specification for properties ought to keep very silent as to composition.

When properties are specified, the end use should be considered. For example, if low-temperature notched-bar toughness is required, testing and selection of heats are required, since different heats have "individuality" in this respect. Thus, a low-temperature requirement may be added to a basic specification when necessary, but it would be out of place in steel for a product not for low-temperature use.

One basic specification, upon which other requirements are superimposed when—and only when—needed, makes sense.

There is, however, no excuse for one irritating situation. The numbering system for steels, started by the SAE, which acts as shorthand to show both the type and the carbon content, is so useful that it remains in most of the various specifications, but the Aeronautical Materials Specifications introduce other numbers which are without such meaning, and which in certain cases are confusing. For example, AMS 6352 is AISI 4130, AMS 5120 is sheet spring stock of AISI 1070, while AISI 5120 is a 0.20 carbon-0.80 per cent chrome steel. We have met cases where subcontractors were badly confused by this usage, and work was held up while they tried to find out what steel was actually called for.

. . . single system not justified nor desirable

By Wm. T. Schwendler

Vice President and Chief Engineer
Grumman Aircraft Engineering Corp.
Bethpage, Long Island, N. Y.

THE aircraft industry already has accomplished a single materials specification system through the establishment of Army-Navy-Aeronautical specifications for all the commonly used materials in airframe construction. These specifications have supplanted Army, Army Air Forces, Navy, Federal, and commercial specifications. Their usefulness has been such that they will continue to be used by most manufacturers for commercial as well as military aircraft .

To many producers of material these AN specifications may appear unnecessarily rigid. Past experience, however, has shown their special requirements to be necessary. These requirements, while adding to the cost of the material, allow the use of small design margins with an appreciable saving in weight. The material cost in a finished airplane is a much smaller percentage of the total cost than that expended for labor. Therefore the additional cost of a rigidly inspected and high-quality material is generally offset by a saving in rejections of finished or semifinished parts.

In industries where weight is not at such a premium, generous design margins may be allowed for inconsistencies in the material and for defects which would make the material unsuitable for aircraft use. This allows the use of material made to quite liberal specifications with resultant lowered material costs. In an industry where material is a greater percentage of the finished cost than for aircraft, the use of "aircraft quality" material cannot be economically justified. It also follows that different industries can tolerate various qualities of material so that several qualities may be justified for each material used by several different industries.

It is therefore believed that a single materials specification system is not justified nor desirable. Elimination of duplication and overlapping of specifications is very worthwhile, however, and effort should be made toward accomplishing this end.

. . . no project more important in standardization field

By Thomas Spooner

Manager, Engrg. Labs and Stds. Dept.
Westinghouse Electric Corp.
East Pittsburgh, Pa.

WE ARE HAPPY to offer our comments with reference to a national unification of materials specifications. In the standardization field we know of no project which is more important.

The following table gives a picture of the multiplicity of the principal agencies in this country which are active in the preparation and distribution of materials standards.

Society or Standardizing Bodies	Comparable Spec. Nos.
Society of Automotive Engineers	1035
Aero. Mat'l. Specs. (SAE sponsored)	AMS 5060
American Society for Testing Materials	A-107
American Bureau of Shipping	
Reference: ABS Stds. Sect. 40, ref. (a), Properties Listed	
American Society of Mechanical Engineers	S6
American Iron and Steel Institute	C1035
American Standards Association	G43.1
Government Agencies	
U. S. Navy	51D6
U. S. Army	100-17
War Dept.	WD-035
Army-Navy	AN-QQ-S-646
Federal	QQ-S-646
Etc., (such as Signal Corps, Ordnance)	
Signal Corps	71-2202
Ordnance	AXS 1084

In addition to much duplication there are too many grades differing in composition by insignificant amounts. In the metals field, both ferrous and nonferrous, the situation is particularly bad. This condition was fully realized before Pearl Harbor and steps were taken, under the sponsorship of the ASA, to correct or at least improve the situation. However, due to the war and the enormous requirements of the armed forces, the specifying of materials was centered largely in Washington, with the WPB taking a large part. Immediately expendiency governed and new war groups entered the field with still further duplication and complication. Cost and efficiency were ignored. With the war over and the cost of materials and labor rapidly rising, efficiency must once again come to the fore.

It is time that industry carried the ball once more with, it is hoped, full co-operation of the government agencies. The Standards Branch of the Procurement Division of the Treasury Department, under the able leadership of Willis S. MacLeod, is already attempting to co-ordinate the government agencies.

We believe it is not the function of manufacturers of materials or even their trade organizations to prepare specifications and assign designations. This should rather be the function of impartial associations made up of users, producers and general interest groups. We believe that of the available agencies the ASA, due to wide membership and suitable procedure methods, is best qualified to do this job.

Just before the war intervened, an ASA committee, under the chairmanship of R. A. Frye of the Westinghouse Electric corporation, was organized to review and co-ordinate the existing steel specifications. There was also authorized the formation of two other committees to function similarly for aluminum alloys and for the other nonferrous metals. However, for the reasons indicated above, these projects were indefinitely postponed. We believe it is now time that they be reviewed and pushed actively to a conclusion. We hope that MACHINE DESIGN agrees and will help in this most urgent co-ordination project of unification of material specifications.

. . . do not believe would serve any good purpose

By KARL D. WILLIAMS
Chief Engineer, Materials
Navy Dept., Bureau of Ships
Washington, D. C.

SPECIFICATIONS are prepared for several reasons. First, to detail the characteristics of a material for the designer or user; secondly, to describe to the purchaser the material desired; thirdly, to inform the bidder and contractor regarding just what is required in filling the contract or purchase order and, lastly, to describe just what inspection and tests are to be made to insure the delivery of material complying with requirements. No specification can be considered complete unless it provides for each of these points.

Specifications differ from standards in that their requirements are generally based on the end use of the products covered thereby. For example, since the end use of a product on shore and on board ship may not be the same, specification for the product may of necessity differ.

Progress in the development of materials is made through specifications. If standards are strictly adhered to, advancement is retarded or ceases altogether.

In view of the foregoing, it is not believed that any good purpose would be served by the establishment of a single materials specification system since each activity using the product covered by a specification should have control in order to insure provisions in the specification for its requirements.

It is believed every effort should be made to establish "standards", not "specifications", for the chemical properties of alloys and for dimensions and designs of products. Such standards should be promulgated, if practicable, by a single agency to the satisfaction of all other interested agencies.

These opinions or assertions are the private ones of the writer and are not to be construed as official or revealing the views of the Navy Department or the naval service at large.

. . . would be welcomed by steel foundrymen

BY CHARLES W. BRIGGS
Technical and Research Director
Steel Founders' Society of America
Cleveland

I AM VERY much in favor of the establishment by one specifying body of a universal set of specifications applying to a single product. I know, from my association with the steel casting industry, that steel foundrymen would welcome one complete set of steel casting specifications which would be used by all purchasers of steel castings. The Steel Founders' Society has for a number of years taken the stand that the steel casting specifications of the American Society for Testing Materials should constitute the only authorized specifications for cast steels and steel castings.

Surely if all buyers and producers of a product would get together to produce a complete set of specifications for all uses of the product, there would be produced acceptable specifications for all.

Personally, I prefer the American Society for Testing

Fig. 2—An overall specification system might be developed similar to that recently adopted for plastics molding materials by The Society of the Plastics Industry Inc. A sample of the new plastics classification is shown below. In this system, grade numbers indicate the basic properties, and suffix letters (M, E, O, T, C and A) indicate the additional properties that are required

GRADE NUMBER	BASIC REQUIREMENTS						SOURCE SPECIFICA	
	Heat Distortion Temp. °F 264 PSI Fiber Stress ASTM D648-41T	Impact Strength Izod Ft.-lbs. per in. notch ASTM D256-43T	Tensile Strength PSI ASTM D638-42T (3) D638-44T (3) D651-44T (4)	Maximum Continuous Service Temp. °F (2)	Heat Distortion Temp. °F 66 PSI Fiber Stress ASTM D648-44T	Material Basic Chemical Analysis (1)	American Society for Testing Materials	Federal
	MIN.	MIN.	MIN.	MAX.	MIN.			
						X	Sa	Sb
SPI 10232	100	2.3	2000		140	CAB	D707-7	
SPI 10252	100	2.5	2000		130	CAB	D707-10	
SPI 10302	100	3.0	2000		120	CA	D706-11	
SPI 10311	100	3.1	1000		130	CAB	D707-8	

Materials' approach to the specification problem, since both users and producers of a product collaborate in the preparation of specifications. Also, there are a sufficient number of general-interest members available to assist in producing the proper solution in case of failure of the user and producer to get together on a subject.

If every one knew that, for example, he could go to the ASTM standards for all cast steel specifications, I believe that there would be fewer private specifications and the foundries would know more about producing castings to the desired requirements.

One of the greatest drawbacks to a single agency's preparing specifications for a product is the Government purchasing bodies. The Government departments seldom use specifications prepared by bodies other than their own; hence it would be nigh impossible for Government departments to accept as purchase requirements, specifications that had been prepared, for example, by the ASTM. In fact, it is very doubtful if they would prepare a specification for Government use that was identical to the requirements of the designated specifying body. In view of this situation, it appears that if a single set of specifications were prepared, the Government would be the body that must issue such specifications.

If such procedure were to be followed, it would be advisable for Government to change its procedure in the preparation of specifications so that other users and all producers of a material could have a voice in the preparation of the specifications. Also, specifications for the complete range of products must be prepared, and not just for those products normally used by the Government departments.

One of the disadvantages of present Government specifications is that for a single product, each of four or five Government departments prepare specifications. For instance, steel casting specifications have been prepared by the Navy Department, War Department, Coast Guard, Bureau of Navigation and Steamboat Inspection of the Department of Commerce. These requirements are in addition to the Federal Specifications for Steel Castings. It would seem that the Government itself has a job to do in preparing a single set of specifications.

The solution to the problem is a difficult one. Perhaps it would be wise to instigate two specification-writing bodies for a single product: (1) The Government, and (2) a single designated body. The latter could be arranged by mutual agreement of all scientific societies and trade associations interested in the manufacture and purchase of the product. It should be the understanding that any organization or any company could request the preparation of new specifications or the revision of standard specifications. The specifications prepared should be given wide publicity so as to prevent the preparation of private specifications.

. . . desirable . . . but realization would be miracle

By G. K. Eggleston
Vice President in Charge of Engrg.
Barnes Mfg. Co., Mansfield, O.

The confusion caused by multiplicity of specifications on like or similar materials during the war period is still very fresh in my mind. Even more exasperating were some of the interpretations made of poorly worded specifications by people not qualified to make interpretations. While I have been exposed to specifications of wide variety, the bulk of them have applied to metals, the copper-base alloy castings in particular. In view of this, the following remarks will be confined to specifications covering brass and bronze castings.

As a basic principle, I believe a single materials specification system is very desirable. But its realization in our time would be a miracle. I believe all the specification-writing institutions would agree to the single system provided it was theirs.

The part of like or similar specifications that apply to the chemical composition of a brass or bronze has been fairly well standardized. Because of this, it is reasonably simple to obtain basic materials of proper chemical composition and to produce castings therefrom of the desired composition. But your troubles start when you try to follow the whims and brain storms of how the physical properties of the resulting castings are to be obtained.

It might be possible to write a specification covering the physical properties of a given casting alloy for a specific or limited field of use. But some common alloys such as the well known 85-5-5-5 have an extremely wide field of use, all the way from castings that must withstand high hydraulic or pneumatic pressure to those used only for ornamental purposes.

This leaves the choice of writing a series of specifications

REQUIREMENTS ADDED BY SUFFIX LETTERS																							GRADE NUMBER
ECHANICAL PROPERTIES				ELECTRICAL PROPERTIES											OPTICAL PROP.			THERMAL PROP.		CHEM. PROP.	AGING PROP.		
Compressive Strength PSI ASTM D695-42T ASTM D649-42T (6)	Modulus of Elasticity in Tension PSIx10^6 (7)	Hardness Rockwell (8)	Specific Gravity ASTM D792-44T (10)	Power Factor ASTM D150-42T			Dielectric Constant ASTM D150-42T			Dielectric Strength Volts per Mil ASTM D149-44T		Volume Resistivity Meg-Ohms cm ASTM D257-38	Resistance		Index of Refraction ASTM D542-43T	Light Trans. % ASTM D672-43T	Haze % ASTM D672-45T	Coefficient of Thermal Expansion Linear in/in/°C x10^{-5} (9)	Rate of Burning ASTM D635	Water Absorption % Net Gain ASTM D570-42T	Weight Loss % (11)	Dimension Change % (12)	
				Cycles			Cycles			Short Time	Step by Step		Insulation Meg-Ohms ASTM D257-38	Arc Sec. ASTM D495-42T									
				60	10^3	10^6	60	10^3	10^6														
MIN.	MIN.	MIN.	MAX.	MAX.	MAX.	MAX.	MAX.	MAX.	MAX.	MIN.	MIN.	MIN.	MIN.	MIN.	MIN.	MIN.	MAX.	MAX.	MAX.	MAX.	MAX.	MAX.	
Mb	Mc	Md	Mf	Ea	Eb	Ec	Ed	Ee	Ef	Eg	Eh	Ei	Ej	Ek	Oa	Ob	Oc	Ta	Tb	Ca	Aa	Ab	
			1.19							250					1.46	80				1.60	2.4		SPI 10232
			1.21							250										1.30	6.0		SPI 10252
			1.32							250										4.50	11.3		SPI 10302
			1.18							250					1.46	80				1.50	3.0		SPI 10311

for the same alloy covering a series of specific uses, or a single specification broad enough to cover the whole field of uses. The use of these broad sppecifications is very liable to increase the cost of castings by unnecessary tests, when the use of the casting does not indicate that such tests are needed.

I would be a little afraid to put a broad type of specification in the hands of an Armed Services inspector because if the designer of the piece had not specifically indicated which parts of the specification did not apply, you would probably find yourself having to do everything that was written into the specification, whether it made sense or not. I think I can best illustrate this by quoting a Navy Inspector's Creed, with apologies to Tennyson: "Ours is not to reason why, ours is but to do and die."

. . . why not adopt a modified SAE system?

By A. O. Wood
Chief Engineer, Tocco Div.
The Ohio Crankshaft Co., Cleveland

WE HAVE felt for some time that steel specifications are becoming increasingly involved and a simplified single specification would be welcome. There is, in many cases, not only an overlap between several systems such as AISI and SAE, but also there are too many divisions within any one system. These two specifications could be simplified, and the Air, Army and Navy could be brought in with AMS for high quality work. In addition to the chemistry, these specifications, as with ASTM, cover the quality, inclusions, finish, etc.

Why not group all under a modified SAE system as regards chemistry, and where further specifications as to quality are to be made, use a prefix or suffix to indicate it? Then the type of steel as well as its quality could be readily recognized.

. . . committees should decide on a single system

By B. F. Jones
Asst. Chief Engineer
The White Motor Co., Cleveland

IN GIVING careful consideration to this question, the first point to be definitely established is the use of the word "materials." Every industry using various types of materials has its own specifications or has adopted some of the standard specifications now existent. In order to properly evaluate the answer to this question, we believe that it should be confined to a certain class of materials, such as steels.

From the writer's experience, we feel that the SAE material specifications for steels are the most complete and comprehensive and are used largely throughout the manufacturing industries at the present time. As evidence of this fact, the writer served on several War Engineering Boards to establish certain specifications, and in nearly every instance the SAE steel specification was used as the basis for compiling various comparative data.

SAE and AISI specifications, of course, follow the same basic numbering system. For example, a plain carbon steel with 45 points of carbon is designated in the SAE list as SAE 1045 steel; in the AISI specifications it is designated C1045. This same similarity follows through the alloy steel range.

Army, Navy, and Federal specifications are based on the same series of symbols which indicate definitely the type of steel by a designated number. It seems that the specifications for steels have been standardized to a greater degree than many other specifications, and we believe that in order to properly evaluate specifications, representatives of the various interested manufacturing groups should form co-operative committees to decide upon a single standard. This type of work is now being carried on by the SAE, which is represented by comittee members working with other technical societies and associations, such as the ASTM, American Standards Association, Federal Specification Board, Radio Manufacturers Association, and American Petroleum Institute.

SAE Number	Nominal Chemical Ranges				Corresp. AISI No.
	C	Mn	P Max.	S Max.	
1008	0.10 max.	0.30–0.50	0.040	0.050	C1008
1010	0.08–0.13	0.30–0.50	0.040	0.050	C1010
1015	0.13–0.18	0.30–0.50	0.040	0.050	C1015
(X1015) **1016**	0.13–0.18	0.60–0.90	0.040	0.050	C1016
1020	0.18–0.23	0.30–0.50	0.040	0.050	C1020
(X1020) **1022**	0.18–0.23	0.70–1.00	0.040	0.050	C1022
1024	0.20–0.26	1.35–1.65	0.040	0.050	C1024
1025	0.22–0.28	0.30–0.50	0.040	0.050	C1025
1030	0.28–0.34	0.60–0.90	0.040	0.050	C1030
1035	0.32–0.38	0.60–0.90	0.040	0.050	C1035
1036	0.32–0.39	1.20–1.50	0.040	0.050	C1036
1040	0.37–0.44	0.60–0.90	0.040	0.050	C1040
1045	0.43–0.50	0.60–0.90	0.040	0.050	C1045
1050	0.48–0.55	0.60–0.90	0.040	0.050	C1050
1052	0.47–0.55	1.20–1.50	0.040	0.050	C1052
1055	0.50–0.60	0.60–0.90	0.040	0.050	C1055
1060	0.55–0.65	0.60–0.90	0.040	0.050	C1060
(X1065) **1066**	0.60–0.71	0.80–1.10	0.040	0.050	C1066
1070	0.65–0.75	0.70–1.00	0.040	0.050	C1070
1080	0.75–0.88	0.60–0.90	0.040	0.050	C1080
1085	0.80–0.93	0.70–1.00	0.040	0.050	C1085
1095	0.90–1.05	0.30–0.50	0.040	0.050	C1095

Fig. 3—Perhaps a single system could be based on that used by the Society of Automotive Engineers Inc. for steels. Specification number indicates the type of steel, nominal amount of predominant alloying element, and nominal carbon content. With appropriate suffixes to indicate properties, this basic system offers possibilities

. . . technical societies must be closely co-ordinated

By Charles D. Townsend
Plant Engineer
The S. K. Wellman Co., Cleveland

THE present varied system of specifications for materials has become extremely cumbersome. The Army, Navy, Aeronautical and Federal, as well as the National Emergency Specifications, were expanded during the war to the extent that every industry was required to purchase raw materials to at least one, if not all, of these specifications. Overlapping and yet different requirements within these specifications caused considerable difficulty in producing the same part for more than one branch of the armed forces.

With the return to normal production these specifica-

(*Continued on Page* 174)

Scanning THE FIELD for Ideas

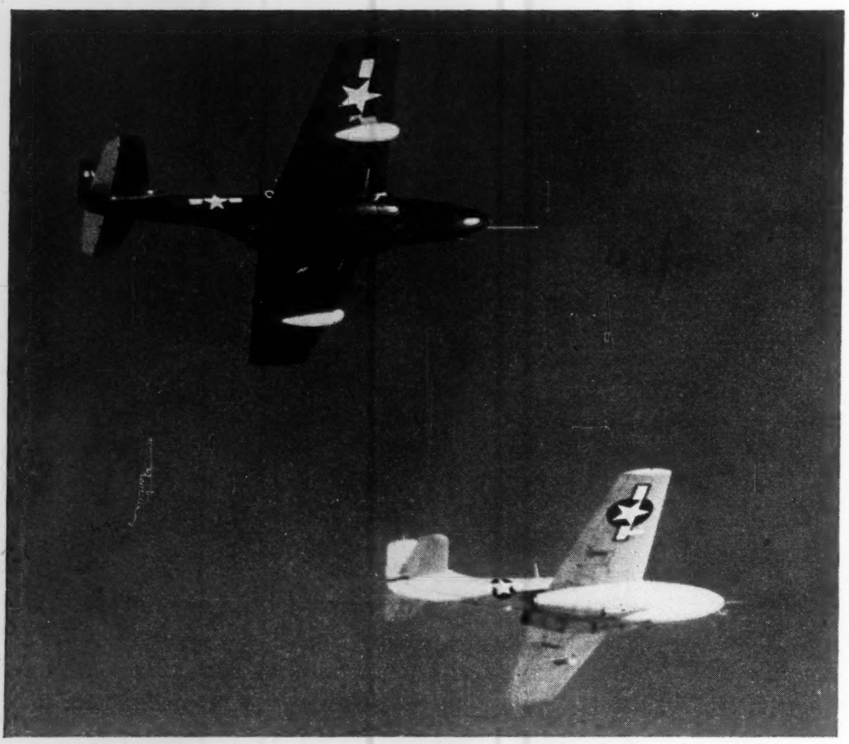
REMOTE control of aircraft by radio promises possible adaptation to commercial and military flying in view of tests recently conducted by engineers of the Air Technical Command and Bell Aircraft Corp. At present, equipment developed by these engineers has been used successfully in obtaining test flight data of maneuvers considered too hazardous for pilots to attempt. Also, in case a test plane should crash, valuable data recorded by the control station is preserved whereas previously it often was destroyed in the accident.

Shown below is a ground control station and televison screen. Images on the screen are drawn by an artist to indicate the horizon of the robot plane. The operator has his hand on the control stick for radio operation of the robot. This control is similar to that in the mother ship.

Most widely influential single factor in the success of the Bell robot plane is a new concept of autopilot, called a rate autopilot. Prior to its conception, research in radio-controlled airplanes was handicapped by the fact that the standard autopilot, also known as a displacement pilot, was effective for normal level flight only. It did not function effectively and lost control in diving or sharp maneuvers because its gyroscope was subject to "tumbling" or "spilling" under such extreme or severe conditions of aircraft flight.

The new autopilot incorporates two rate-of-turn gyro instruments. One spins in a vertical axis to sense change of pitch while the second senses rate of roll. Both sensing devices, the rate autopilot and the displacement autopilot are coupled in an electrical bridge so their functions are interchangeable. Flight and ground stations have a switch which permits selectivity of the autopilots. A miniature stick, similar in operation to the stick in normal planes is mounted on the stick in the mother ship and another miniature stick on the ground stationed so that the

FAN
ON
OFF
24V
50V
ON
CAMERA
OFF
BRIGHTNESS
SYNC
CONTRAST
FOCUS
DIAL LOCK
FREQUENCY
15 AMP
10 AMP

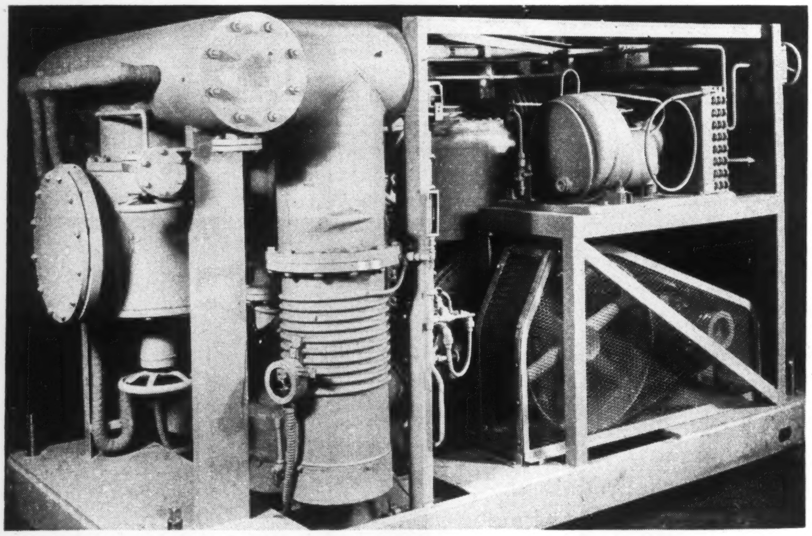


robot can be controlled by sight or by observation of its televised flight instruments.

Such parts of the robot as throttle, flaps, landing gear, brakes, etc., are actuated by servo motors which derive electrical power from circuits controlled by the radio receiver. Flight research measurements such as vibrations, accelerations, structural loads and strains, and other stresses are transmitted to the ground station by the telemetering process. This information is fed in sequence to the transmitter at the rate of 1100 complete cycles per second and transmitted to the ground station where receiving equipment unscrambles the combined signals and feeds them appropriately into separate receiver channels for either recording or observation in a multichannel oscillograph. Shown above are two jet-propelled P-59 Airacomets with the controlling flight station or mother ship above the robot aircraft.

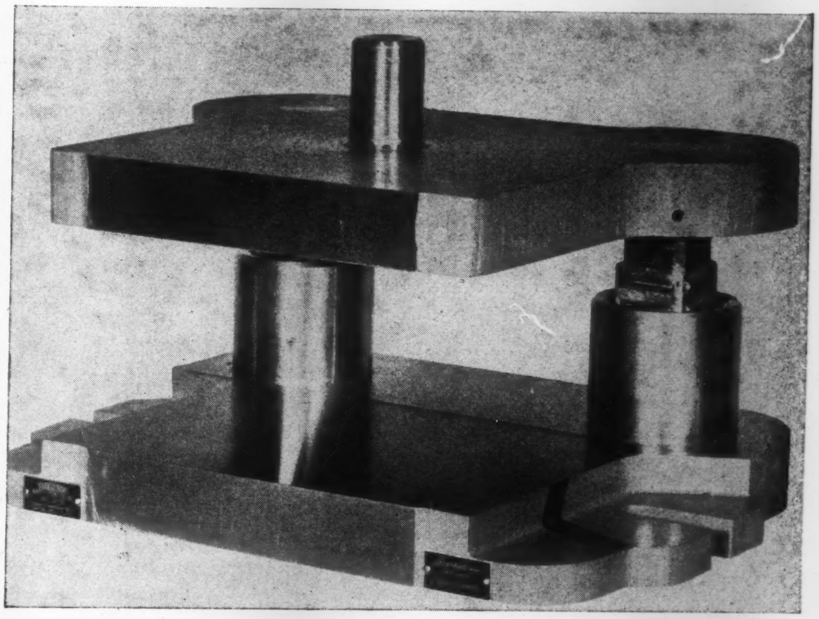
Evacuating large volumes of air or other gases became necessary during the war for certain processes, but no equipment other than small laboratory units was capable of producing vacuums of the order required. Huge pumps for drawing vacuums of one millionth of a millimeter of mercury were required in quantity. Because no rotary pump could do this job alone, the unit shown below was developed by Westinghouse to utilize rotary and diffusion pumps in series.

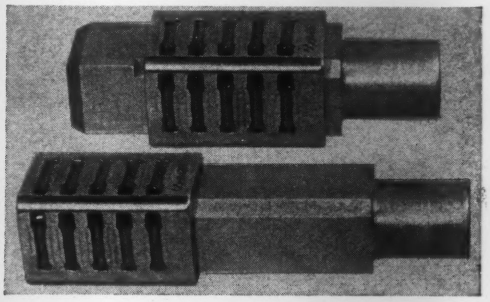
Diffusion chamber consists of a vacuum-tight cylinder with water-cooling coils on the outside. In the inside is a jet assembly. A pool of oil in the base of the cylinder is heated and the oil vapor passes up through a central pipe in the jet assembly and, on reaching the top, is deflected downward by the jet as a cone-shaped spray against the wall of the cylinder. This downward moving oil vapor traps and carries out the gas molecules from the region above. The vapor is then condensed by the water-cooled wall of the outer cylinder and returns to be used over again. Thus the gas is concentrated sufficiently so that it can be pumped off by the rotary pump in series with the diffusion pump.



Fatigue testing by vibration of cords for tires, belting or other products utilizing fabrics, as well as filaments for other purposes is accomplished in special apparatus designed by the B. F. Goodrich Co. When it became apparent that selection of cords suitable for service in tires on the basis of tensile strength alone did not provide completely reliable data the tension vibrator test machine was developed. In some cases it was learned that the fatigue resistance of the used cord had decreased to the failure point while the tensile strength actually had risen. To determine fatigue resistance the material being tested is suspended under static load and the upper grips placed in rapid vertical oscillation. This can be made so much faster than the natural frequency of the loaded cord that the lower weights cannot respond and therefore remain substantially motionless. By using these imposed frequencies well above the resonance frequencies of the loaded cords, close comparisons of nearly similar cords can be made. Successful tests have been made with the weight on each cord between 3.4 to 5 pounds, a vibration frequency of 3600 cycles a minute and a displacement of 0.0032-inch. When a less sensitive differentiation is desired, a displacement of 0.0064-inch and a frequency of 2700 has been found suitable. Conditions of testing may be varied over a wide range and temperature may be controled up to 340 degrees Fahr. in the machine, shown below.

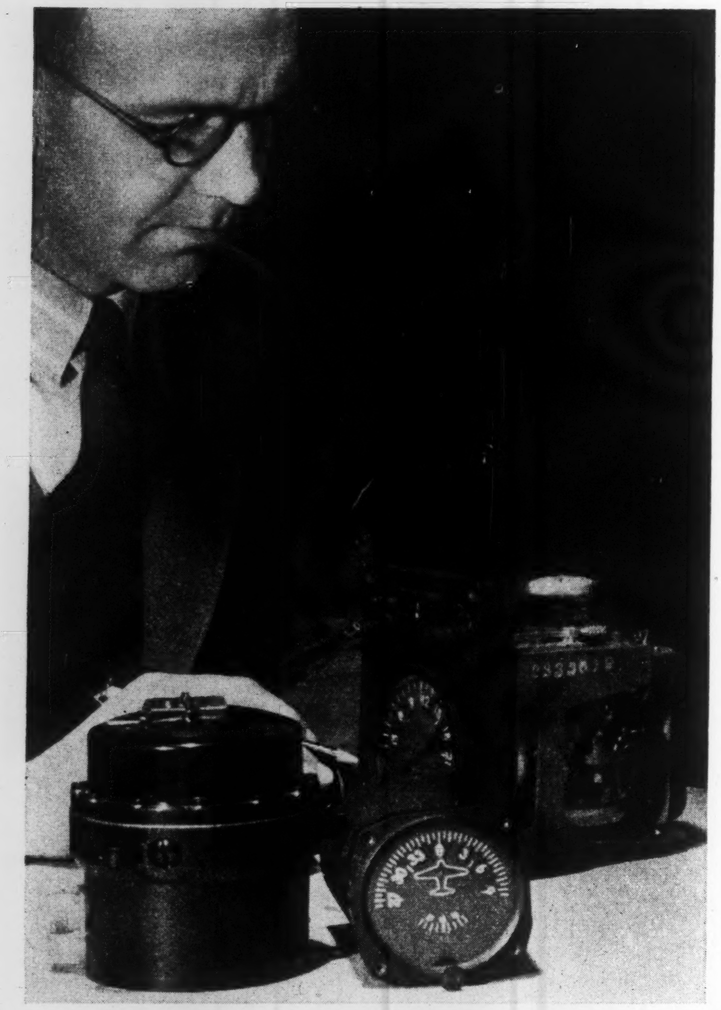
Square pin roller bearing assemblies are utilized in high-speed die sets so that the guide pins will not freeze because of the friction developed. Shown below is such a die set and pin assembly designed by Lempo Products Inc. for use on high-speed punch presses. Preload of 0.0015-inch is set up on the bearings.





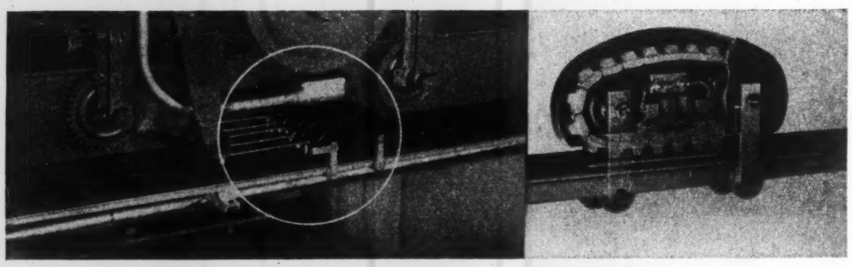
After a test run of 18,000,000 strokes a preload of 0.0005-inch remained, indicating that the play between guide post and bushing may be kept to a minimum. Guide pin holes for the set are bored in the punch holder and die holder in the same operation to obtain commercially perfect alignment. The guide pins themselves are specially formulated wear-resisting alloy steel, hardened and ground to close tolerances. All flat contact areas are precision ground to fine finishes.

Directional accuracy, except for wind-drift deviations, in aircraft flights controlled by autopilots is maintained by a new system of instruments,

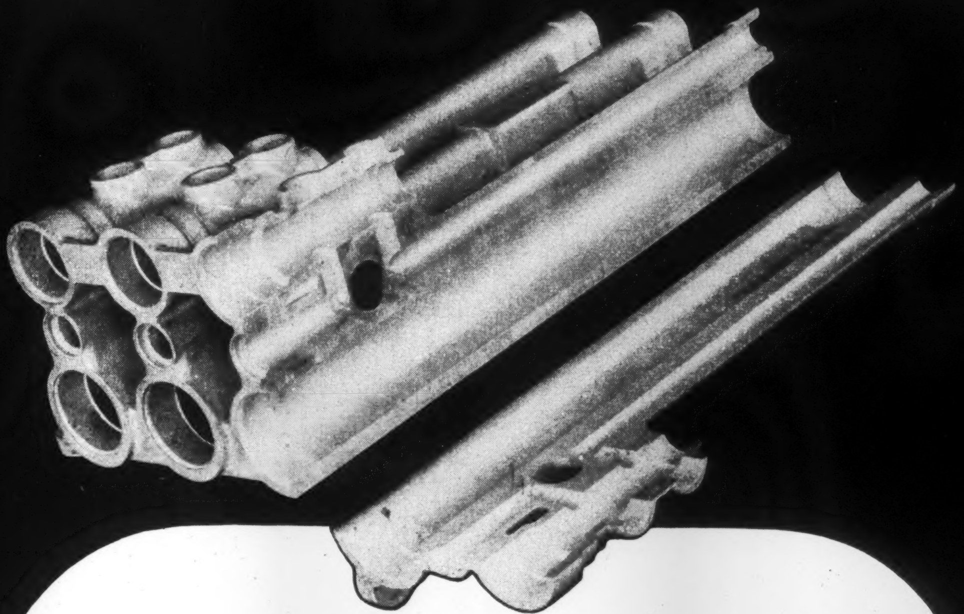


obviating gyroscope corrections by pilot or navigator. In this system, known as the compass-controlled directional gyroscope, the compass and gyroscope are harnessed into a steady computing unit through an electrical coupling with the result that errors which normally would occur in either instrument operating separately are corrected automatically. Shown at left are the units of the new system compared with a gyro in the background which is replaced by them. The compass is remotely located in the plane, usually far out on a wing so as not to be disturbed by metal or other equipment in the cockpit. An electrical transmitter connects the compass impulses to the gyroscope instead of to instrument dials in the cockpit as formerly. The gyro is smaller than previous designs and has unlimited universal freedom of motion.

Travelling collectors with contacts on an endless chain are employed in a trolley system shown below for obtaining power from conductors which are protected against accidental contact. The system, developed by the McCarty Co., utilizes copper conductors encased in slotted rubber racks supported by rigid backing. The "tractor tread" collectors effect positive six-tooth multiple contact at all times. Arcing and pitting are obviated and the wear factor on the contacts is extremely low compared to that from conventional trolley wheels or shoes.



Steering in confined spaces is facilitated in a new design illustrated at left, showing a Baker-Raulang industrial truck. The articulated frame permits swinging the load to line it up in position without lining up the truck itself. Because of this the truck requires about 3 feet less aisle space when placing loads at right angles. It also operates with less clearance on turns. Usual steering knuckles, levers and rods are absent in this unusual design. Steering is provided by power articulation about a vertical hinge point located between the nonsteering axles. A motor-driven gear pump supplies oil through metering valves to a hydraulic piston which terminates in a rack engaging a large bull gear. Operator's control lever closes a contactor which starts the pump motor and operates the metering valve, admitting oil to the cylinder. Fork hoisting and tilting are similarly operated from the same power supply.



Magnesium Die Castings

By Ralph M. Heintz
Vice President and Secretary
Jack & Heintz Inc.

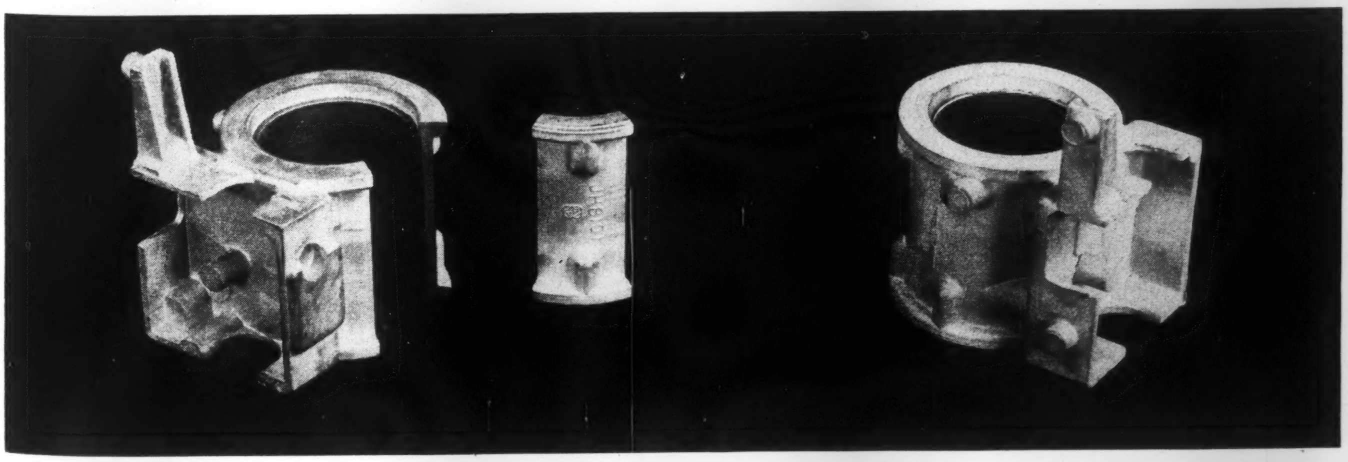
Part II—Design Kinks

ONCE A designer becomes fully acquainted with the nature and characteristics peculiar to the pressure casting technique, he will find that by some native ingenuity various short-cuts and "tricks" can be developed to improve the die-cast parts he designs as well as to decrease costs.

A good example is shown in *Fig.* 1. This is a triple cylinder "servo" unit which actuates the control surfaces of an airplane as part of an automatic flight control system. At first these units were sand cast but the shop

Fig. 1—Above—Cylinder unit of servo for automatic pilot has wrought magnesium tubes die cast into magnesium body

Fig. 2—Below—Cylinder for buzz-bomb servo is example of part in which nitrided steel sleeve is die cast in place



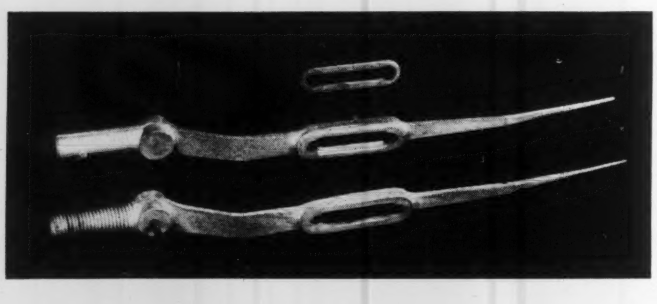


Fig. 3—Left—Magnesium pointer arm has hardened stainless steel insert die cast in place. Threads were cut directly on the unsized "as-cast" cylindrical end

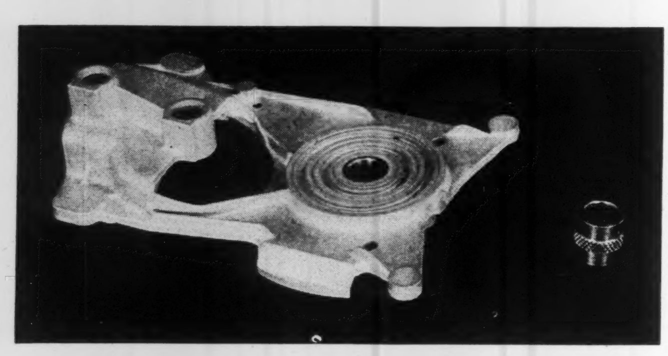


Fig. 4—Left Center—Magnesium contracts radially or expands axially around "cast-in" stainless steel bushing, holding it securely throughout wide temperature range

shrinkage was large because porosity or blowholes uncovered in the boring operations made some of the pieces useless. Generally this cause of rejection was not discovered until the machine work had progressed to a considerable extent or, which is worse, was not discovered until final inspection. The specified requirement that the bores be "true, parallel and free from roughness, porosity or blowholes" caused the rejection of finished and partially finished pieces to become alarmingly high and it was found to be cheaper to machine this piece from a solid aluminum alloy forging.

At this stage it was required to produce the same piece in connection with an automatic pilot. Schedules could not be maintained if either of the foregoing methods were employed, so the piece was designed for die casting in magnesium alloy. To be sure of the machined surface at the bores, wrought magnesium tubes were cast into the die-cast magnesium body. By having the wrought tubes extruded from the identical alloy as that used for the castings, contamination on remelting was avoided and all trouble in the shop ended. Not only were the three main bores so lined but the valve bore as well. The requirement of 15 microinches finish was met easily with one pass of a broach. The machining time for the bores thus was cut from over two hours to three minutes.

A similar piece is the cylinder for a servo unit used on the JB-2 buzz bomb. In this case, because the bore had to be hard a thin steel sleeve was cast into a light metal housing. In such cases where extreme hardness is desired

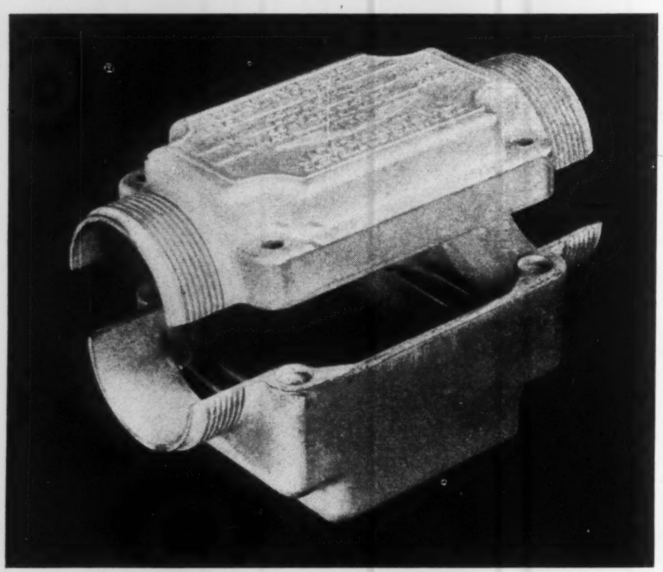
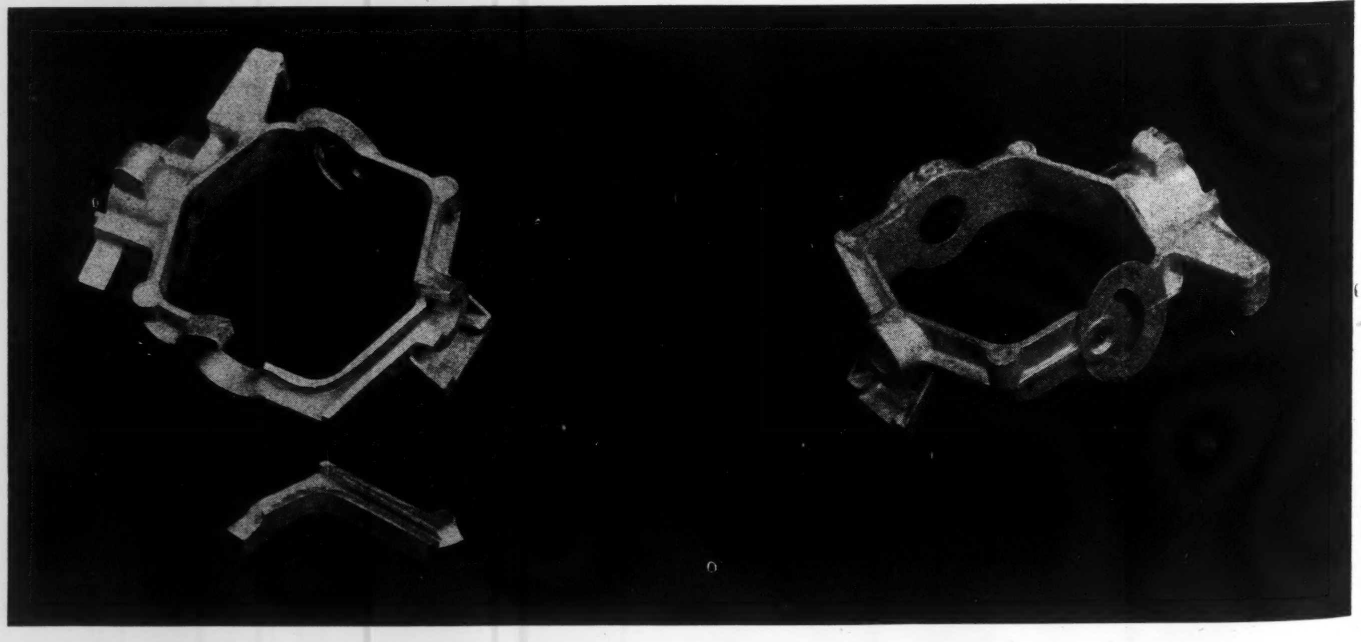


Fig. 5—Left—Threads are die cast onto the members of this relay case and require no finishing operation

Fig. 6—Below—Sectioned gyro gimbal at left shows angular air passage which is cast in without difficulty



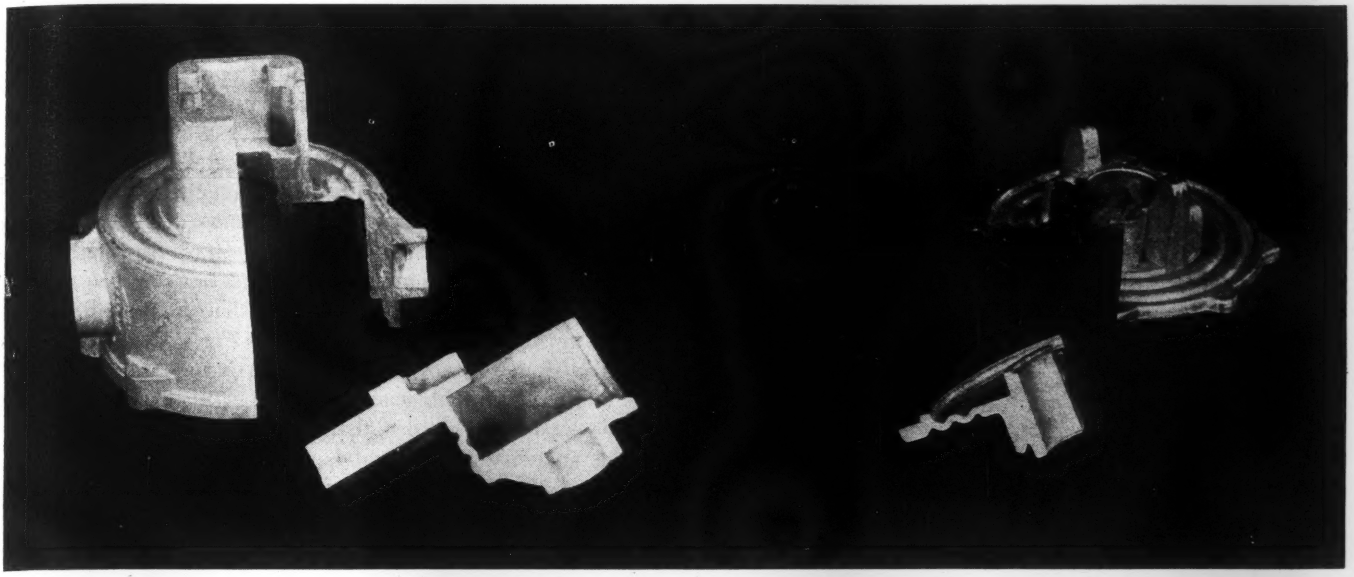


Fig. 7—Above—By die casting the ends of this gyro housing and cover very thin and corrugated in shape, extra flexibility is obtained, in this case to the extent of 0.010 to 0.015-inch contraction or expansion

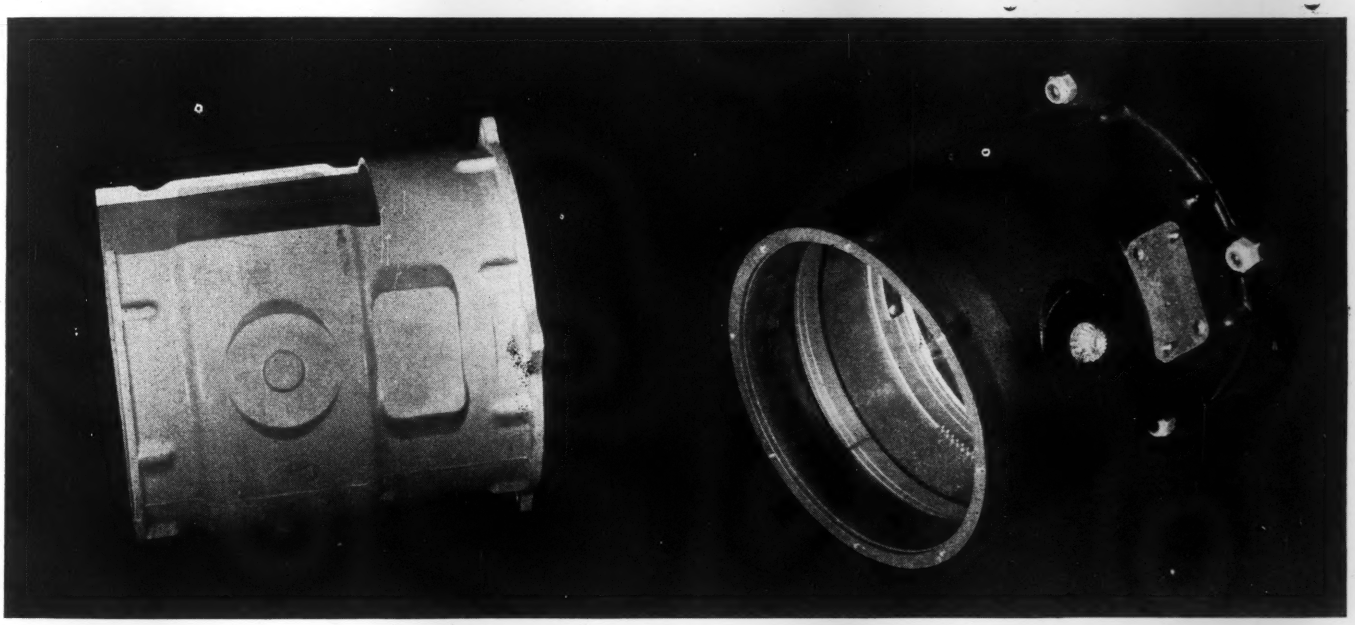


Fig. 8—Below—Section through flight instrument housing, left, shows insert of same alloy as housing die cast in place. Assembly, right, shows smooth internal groove obtained through removal of insert by machining

the liner is made of a nitridable steel and nitrided before die casting into place. This application is shown in *Fig.* 2.

A different type of hardened insert is shown in *Fig.* 3. This is a slide member which is cast into a magnesium pointer arm. In addition to the hardness required corrosion resistance is also necessary, so the insert is punched from a cutlery type of stainless steel and hardened before casting into place. Here, too, is a good example of cutting threads directly onto a die-cast round section without the need of a sizing operation.

Shown in *Fig.* 4 is a stainless steel bushing cast into a magnesium member for expansion control. By deeply grooving the bushing, the magnesium, because of its higher specific expansion, either contracts radially or expands axially, keeping the bushing tight throughout a wide temperature range.

Considerable savings often can be effected by casting, rather than cutting threads. A case in point is the relay case of *Fig.* 5 wherein the threads are cast, half and half, on the two members of the unit assembly. This is a widely used application and serves to illustrate the ease with which threads, ribs and the like can be cast in extremely thin section, to size and in place.

Employment of angular parting lines is illustrated in *Fig.* 6, which is presented to correct a rather general impression that die-casting dies must always separate at 90 degrees. Here all of the flat and 90-degree faces, bores and holes are maintained and yet an angular air passage is cast in without difficulty.

To provide extra flexibility the ends of the gyro housing, *Fig.* 7, are cast very thin and are corrugated. In this case the wheel bearings are kept at a constant clearance by means of a strut passing through the wheel axis and anchored in tension to the housing covers. By corrugating

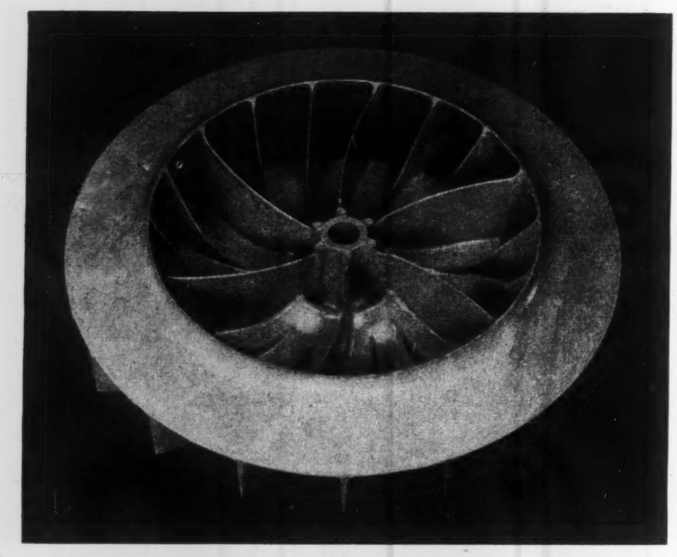


Fig. 9—Example of complexity of shape obtainable through die casting. In this fan, parting line is slanted from inside of front shroud to outside of back shroud

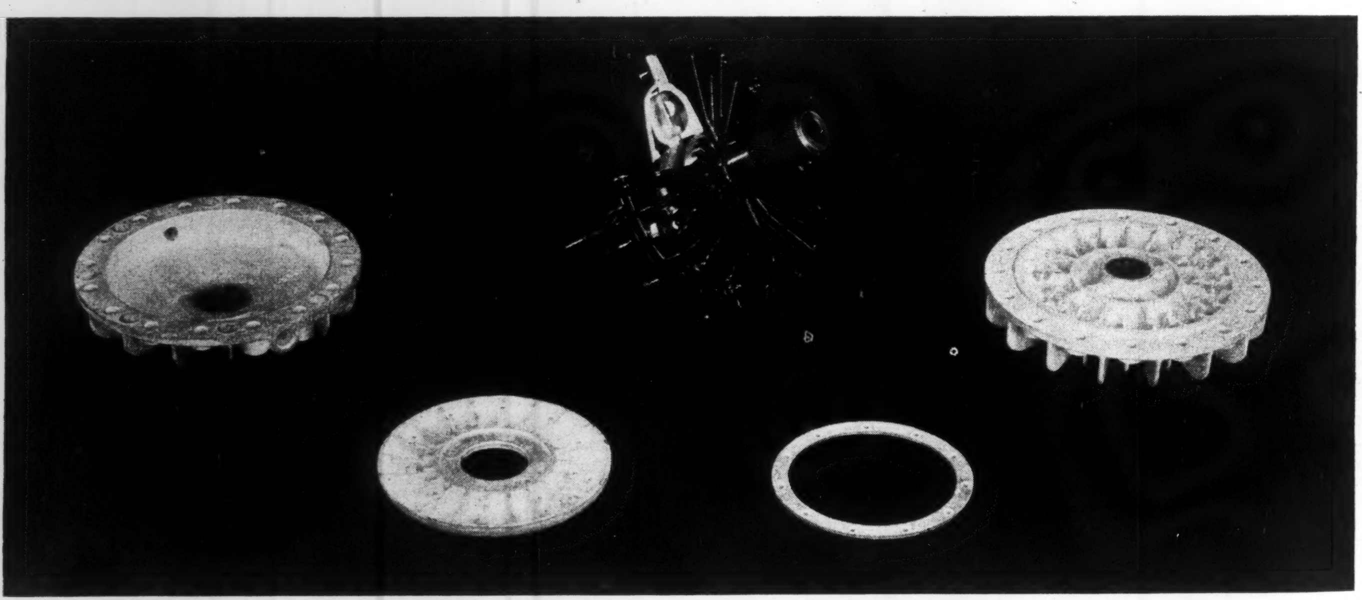


Fig. 10—Above—Rotor and housing of fluid coupling showing cast-on rivets that head-over without fracture

the box ends the metal can contract and expand, which it does to the extent of 0.010 to 0.015-inch without either stressing itself beyond its elastic limit or putting undue stress on the strut. This application should encourage the use of die castings for pressure diaphragms, etc.

A quick method of providing internal reliefs, grooves or undercuts without resorting to complicated collapsing punches is shown in *Fig.* 8. Here a simple die-cast ring is slipped onto a punch and cast into the housing. In the machining operation the ring is turned away, leaving a groove with a sound surface. This is a good illustration of the fact that a light alloy can often be cast against the same light alloy without fusion simply because the cast-in piece is chilled, in this case by the punch.

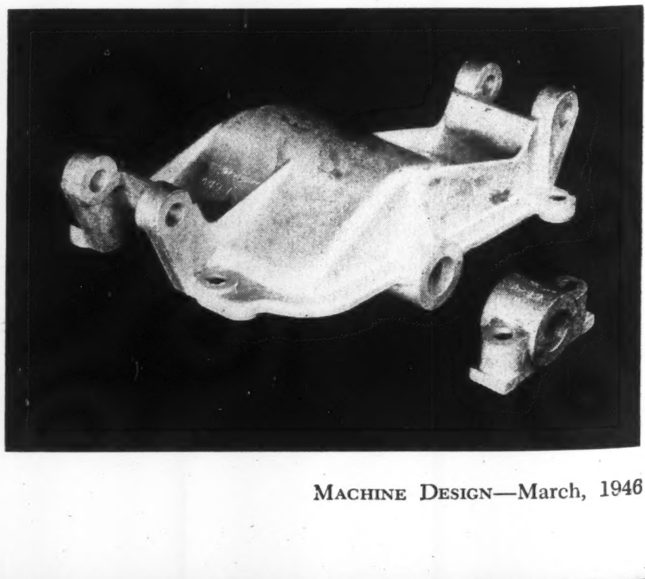
Both the front and back shrouds of the fan, *Fig.* 9, are cast integral. The parting line is simply slanted from the inside of the front shroud to the outside of the back shroud. The small step where the draft reverses on each blade is negligible. This fan, cast in magnesium, is 14 inches in diameter and can safely absorb over 10 hp at 6000 rpm. The center spline can be cast in if desired.

Shown in *Fig.* 10 is a small fluid coupling wherein the rotor and housing are cast to size and, in addition, provide integral rivets for affixing the baffles which likewise are die cast. Even though die cast, the metal is amply ductile to head over with a high-speed hammer without fracture.

In many applications it is cheaper to make use of the good bearing qualities of magnesium alloys especially, and to some extent aluminum alloys, and bore or broach the bearings into the piece itself rather than fit a bushing. A good illustration of this is shown in *Fig.* 11. The part is a valve shaft support wherein the shaft runs directly in the magnesium. In this case it is cheaper to throw the whole piece away when worn than to provide bushings. Tests have shown that the magnesium shows no appreciable wear after a thousand or more hours of continuous operation with full load on the engine.

A good example of how many things can be accomplished in a single casting is illustrated in *Fig.* 12. Here two pump housings, ports, baffles, connecting passages, filter mount, transfer port holes and legs are cast in a single unit,

Fig. 11—Below—Magnesium has good bearing qualities. In this valve-shaft support no bushings are employed



reducing the machine work to a trivial amount. The piece thus becomes cheap enough to throw away should wear show up at the pumps.

Shown in *Fig.* 13 is a cylinder head of an engine of high specific output. This part serves to emphasize the ease with which thin ribs of great depth can be handled by die casting. Here, also, the spark plug insert of aluminum bronze is cast in place. A single groove is ample to insure against leakage throughout a wide range of temperatures. This head would be too difficult to cast in sand and, if it were redesigned for sand casting, would be inadequately finned.

In the foregoing are given a few examples of design short cuts that should encourage the selection of die casting as a technique, better in many cases than other methods of fabrication. Additional notes that should help in considering and applying the process are:

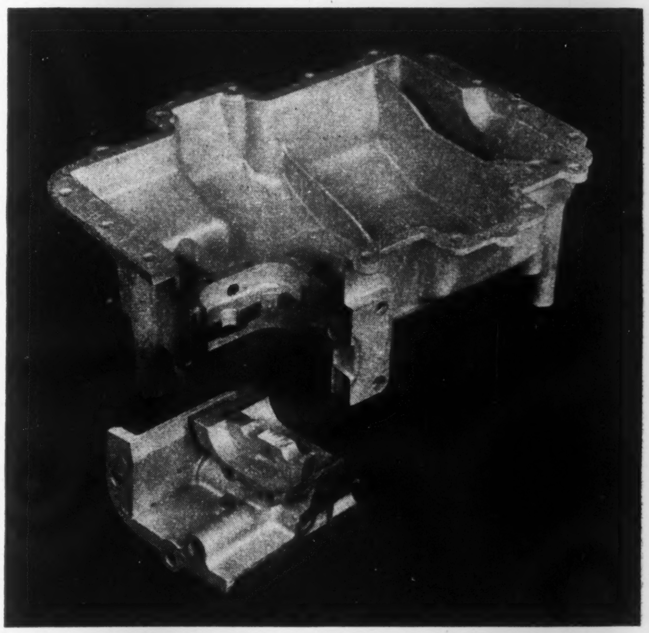


Fig. 12—Right—Die cast into this oil pan are two pump housings, ports, baffles, passages, filter mount, etc.

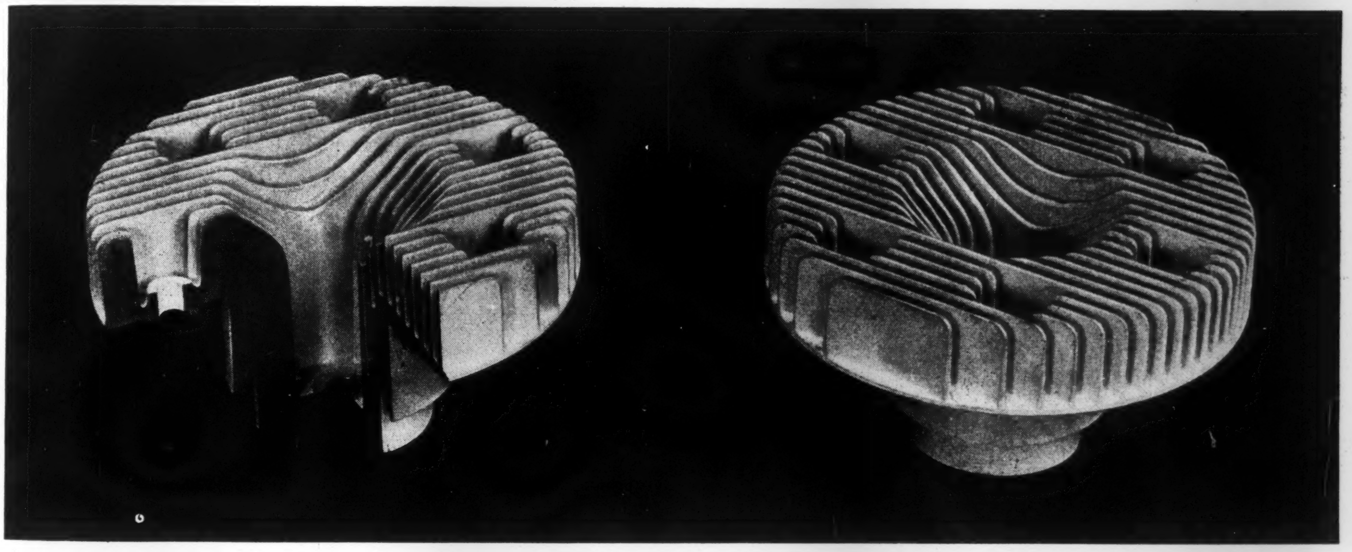


Fig. 13—Above—Cylinder head for gas engine exemplifies great depth of thin fins obtainable by die casting

1. Holes to be tapped should in general be cast to tapping size. First-thread relief should be cast in. Holes for pipe threads should best be cast tapered to receive the tap. The top-thread relief and radius should be cast in. Relief for Rosan or similar lock rings may be cast to size.

2. External threads of 18 pitch and coarser often can be cast to size or at worst need only be skimmed with a die. Such cast threads are stronger and less liable to gall than cut threads. Integral, breach block or multiple threads often can be cast on more cheaply and sometimes to better advantage than providing them by machining.

3. Certain worms and some gears when simple and relatively coarse in pitch can be cast, especially bevel gears. Racks can be cast onto a structure with ease and for hand-actuated mechanisms have sufficient strength and life.

4. Cams, ramps, risers and the like can be cast accurately and, with roller followers, have long life. Such applications would include those in computers, counters, adding machines, etc. Where greater strength or wear resistance is called for, steel cams can be cast in, or on.

5. Composite structure can be resorted to with good results. Rods or punched members can be cast in for strength or expansion control. Electrical heating units sometimes are cast in, as in flat irons. Magnets such as those of the Alnico group often are cast into magneto rotors or stators. Laminations can be cast in without great difficulty, a practice successfully used in magnetos and certain small motors.

6. Die cast pieces often serve as inserts in plastic moldings, thus saving machine work and the need of fastening by riveting or other means.

7. Certain electrical windings can be cast in place. Such an application is the casting of the conductors and end rings into induction-motor rotor laminations, a practice widely used throughout the motor industry. Rotors from 1 to 32 inches diameter are in daily production.

8. Corrosion resistant alloys such as 8 per cent magnesium-aluminum alloy (Alcoa 218) open the use of die casting to marine hardware, boat propellers, bus and truck parts and food machinery.

Ball Integrator Averages Sexta

By R. F. Deimel and William A. Black

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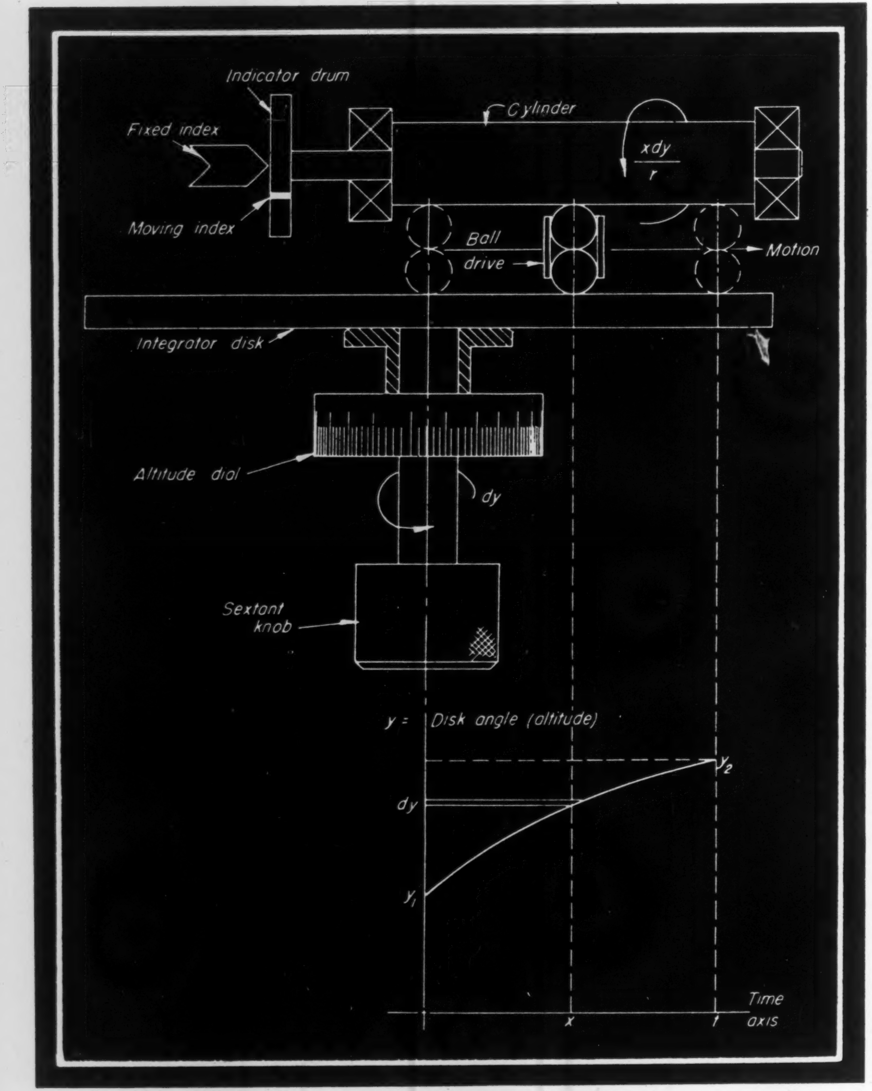


Fig. 1—Heart of averaging mechanism is the ball integrator, shown here schematically. Disk shaft is geared to rotating mirror or prism as well as to a counter. As cylinder and disk rotate, ball drive is pulled toward disk periphery by helical springs, its speed from center to edge of disk being held constant by balance wheel and escapement clockwork

In the early form of the sextant, still used at sea, a telescope is leveled by sighting on the horizon. A mirror, rotatable about an axis transverse to the vertical plane through the telescope axis, is turned until the image of a star, reflected from it, is again reflected from a stationary mirror, in front of the telescope, back through the eyepiece. The star image then appears on the horizon and the angle through which the mirror has been turned is half the altitude or angular height above a horizontal plane tangent to the surface of the earth. The two mirrors are parallel at zero altitude.

On an airplane a telescope sighted on the horizon dips below the horizontal because of the height of the plane above the earth's surface. Sextant observations would therefore have to be corrected for the dip. Usually no horizon is visible because of clouds, mountains, or darkness. It is therefore necessary to use an artificial horizon. In a sextant for aerial navigation, called a bubble sextant, the image of a bubble in a circular level is reflected into the eyepiece. When the bubble is in the center of its field the telescope is level and the axis of the rotating mirror is horizontal.

Why Averager Is Needed

Consider now the difficulty of using a sextant from an airplane. Under the best of circumstances the plane in straight horizontal flight is continually changing its attitude because of rolling, pitching, yawing, and slight deviations from its course, and the navigator must keep moving his instrument to hold it level. As these motions are periodic, the bubble responds to their accelerations by oscillating about its normal central position. There is thus no assurance that the level on the telescope is horizontal even when the bubble is centered. Add to these difficulties the fact that a star is rising or falling at a rate which might be as large as a quarter-degree a minute, and the need for averaging a reasonably large number of observations becomes evident.

Readings

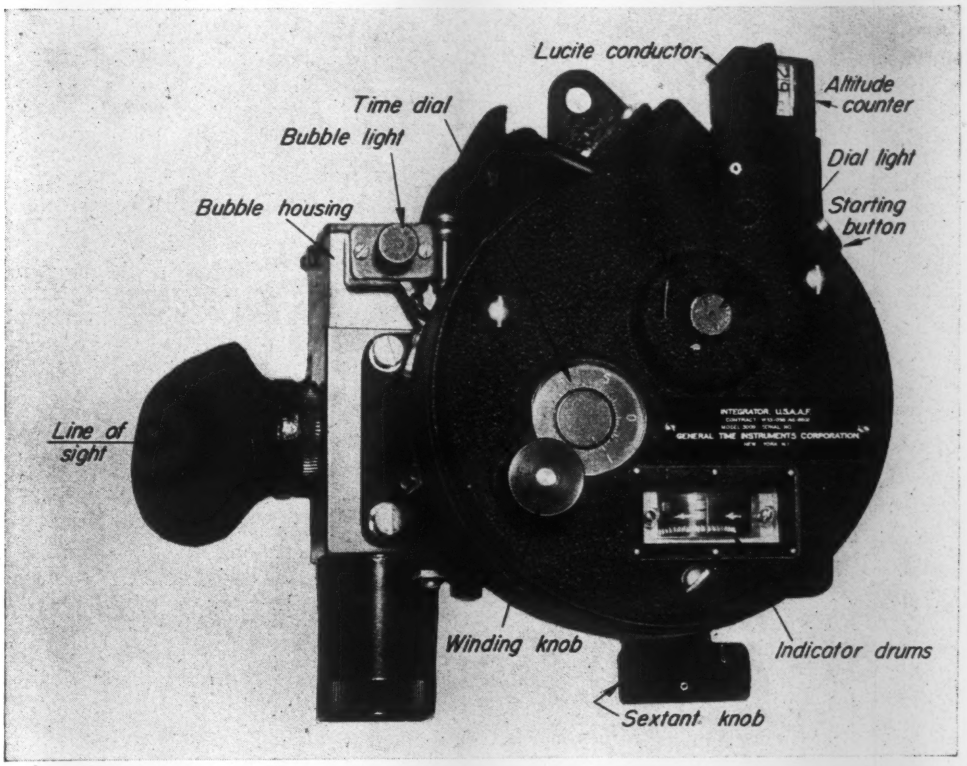


Fig. 2—Key outer components of averaging sextant are shown in this side view. Illumination of time dial, indicator drums and altitude counter is transmitted from the dial light through Lucite conductors

In using a sextant equipped with an "averager" such as is discussed in the following, the navigator keeps a star continually set on the bubble for any desired period of time up to two minutes, which is considered to be the longest necessary. During this period of operation an index on a dial turns away from a fixed mark. When the last sight has been taken, the dial is turned back until the index is again on the fixed mark. The average altitude then appears on the sextant counter. Turning the dial and reading the counter takes only a few seconds, constituting a considerable saving in time over the previous method.

Advantages of this averager over other types are:

1. It uses continuous observations that require no recording. Thus there are many more "shots" in a short time.
2. Observations need not be made for a predetermined fixed time which might be interrupted by the sudden appearance of a cloud or an enemy.
3. It gives the mean value, that is, the average height of the curve of altitude plotted against time without, however, plotting the curve. Unless the method of least squares is used, the mean or average is the "best" value if the errors of observation have random or cyclic distribution. A correct result cannot be found from values that are preponderantly high or low.
4. The mean value is read immediately on a counter without calculation or inspection of a chart.

Principal parts of the instrument are shown schematically in *Fig.* 1. The shaft of the disk is geared to the rotating mirror (or prism) and to a counter that reads degrees and minutes. Turning the sextant knob therefore rotates the disk and the mirror and registers the motion on the counter. The balls are in a sleeve, and springs on the bearings of the cylinder produce enough pressure to enable the balls, through frictional contact, to transmit the motion of the disk to the cylinder.

Connected to the shaft of the cylinder is an index which rotates with it. When observations begin, the index is set to zero by a heart-cam mechanism which will be discussed later. The ball drive is mounted in a carriage which slides radially parallel to the face of the disk. When observations begin, the ball drive is set on the center of the disk and moves outward. The carriage is pulled outward by a pair of helical springs and the speed of the carriage is kept constant by a balance wheel and escapement clockwork mechanism.

Winding the clock simultaneously brings the balls to center and sets the index to zero. In *Fig.* 1, y is the angle through which the disk (or mirror) has been turned during the time it has taken the ball drive to move out to position x from the center; y_{av} is the average angle, and the time of observation is t. Then

$$tv_{av} = \text{Area under the } (x, y) \text{ curve}$$

$$tv_2 = \text{Area of dotted rectangle}$$

$$\int_{y_1}^{y_2} x\,dv = \text{Area above curve}$$

whence $$tv_{av} = tv_2 - \int_{y_1}^{y_2} x\,dy$$

or $$y_{av} = y_2 - \frac{1}{t}\int_{y_1}^{y_2} x\,dy \qquad \text{......................(1)}$$

An increment of angle dy of the disk, with ball drive at x, turns the cylinder, of radius r, through an angle xdy/r and the total drum angle is

$$\int_{y_1}^{y_2} \frac{xdy}{r}$$

The disk and cylinder, in position t, are geared in the

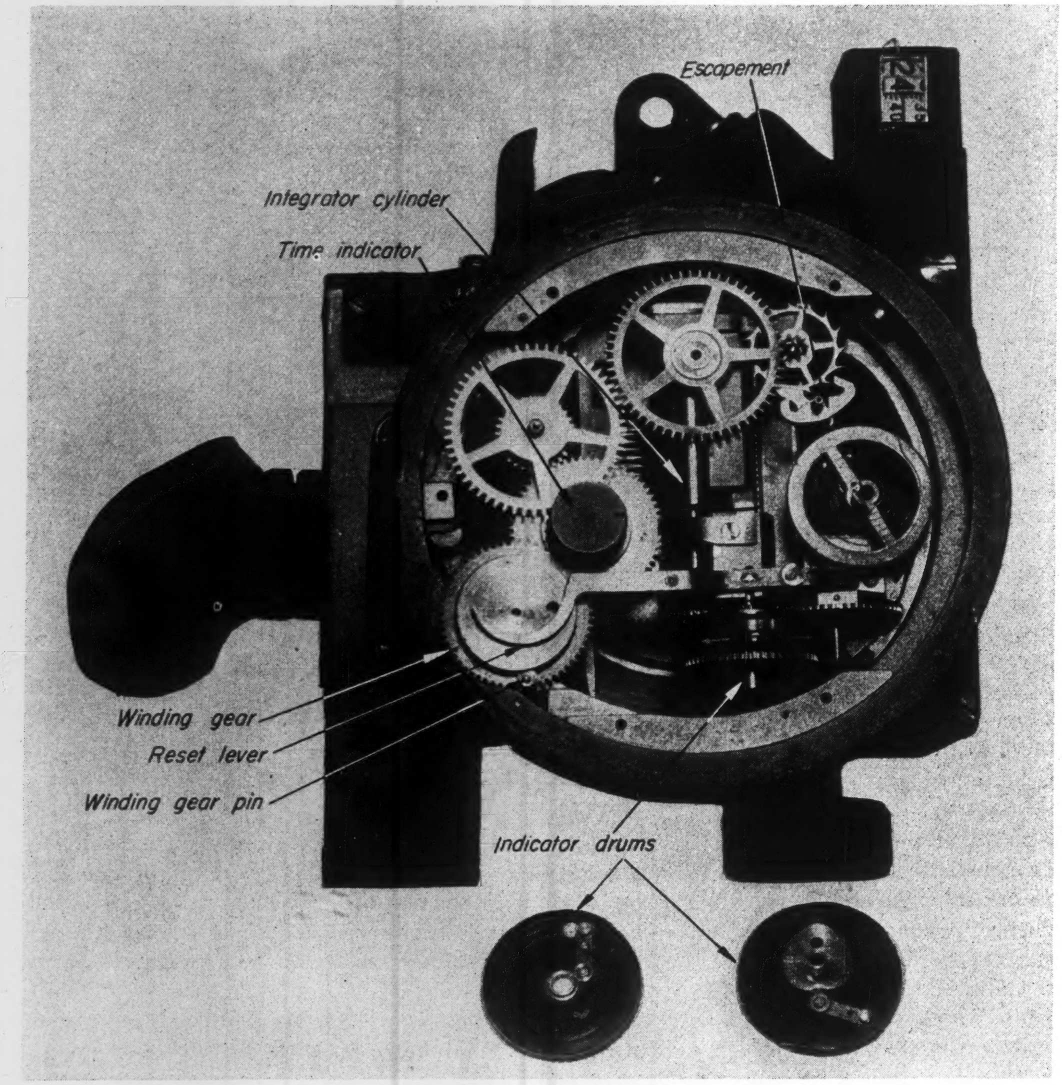


Fig. 3—View of mechanism with cover plate removed shows winding-gear train, escapement and (below) heart-cam mechanism in indicator drums which sets index to zero

ratio r/t. Turning the cylinder back to its initial position through an angle

$$\int_{y_1}^{y_2} \frac{xdy}{r}$$

turns the disk back an amount

$$\frac{r}{t}\int_{y_1}^{y_2} \frac{xdy}{r} = \frac{1}{t}\int_{y_1}^{y_2} xdy$$

and thus, according to Equation number 1, subtracts this term from y_2 and sets the counter to the average value y_{av}.

In obtaining the mean altitude of a star the following sequence of operations is required:

1. Winding knob, *Fig.* 2, is turned clockwise as far as it will go (about half a turn).
2. Sextant, *Fig.* 2, is oriented to make the line of sight horizontal and the plane of the nameplate vertical with the sextant knob down. The proper orientation is secured when the bubble that is visible in the eyepiece is centered in its circular field.
3. Sextant knob is turned until star image is on bubble.
4. Starting button, *Fig.* 2, is depressed and held down while the sextant knob is turned to keep the star on the bubble.
5. Button is released if it is necessary, or desired, to terminate the observations before two minutes have elapsed. (The instrument ceases to operate at the end of two minutes which is believed to be the longest time necessary to include the longest cyclic oscillation of a plane in its course. Observations continued after the two-minute period are not recorded by the instrument and do not affect the average altitude).
6. Sextant knob is turned to rotate the lower indicator drum, *Figs.* 2 and 3, in the direction of the arrows until the index on the upper drum is brought into alignment with the index on the Lucite window.

Considering now the functions of the mechanism in these operations, the winding operation serves four functions: Moving the drive balls to the center of the integrating disk, energizing the drive springs, returning the time indicator to zero, and returning the indicator drums to their starting position.

The winding knob is mounted in an independent bearing directly above and concentric with the winding gear, *Fig.* 3. A disk, not shown, fixed to the winding knob shaft carries a pin which engages the winding-gear pin. When winding, the knob is turned in a clockwise direction as far as the movement of the winding gear will permit. When the knob is released a return spring causes it to assume its initial position leaving the winding gear in its fully wound position. Thus the knob will remain stationary during the unwinding period, thereby avoiding the danger of interference with the timing mechanism which would arise if a rotating knob were accidentally touched.

Motion of the winding gear is transmitted to the ball carriage through a gear train terminating in a rack on the carriage. An externally adjustable carriage stop makes it possible to stop the winding movement when the ball drive shown in *Fig.* 4 is precisely centered on the integrator disk. In this position the two drive springs are fully stretched, tending to drive the timing train shown in *Fig.* 3. The cylinder is carried in ball bearings mounted in a pivoted yoke which is spring loaded to produce the force necessary for frictional engagement between the cylinder and integrator disk through the medium of the two balls which are retained in a hardened and lapped steel sleeve. A single ball would have been sufficient had it been necessary to transmit rotational movement only, but two balls are required to permit free rolling in a radial direction on the disk as the carriage moves on its guide rails.

The holding ratchet and click, common in clock-winding mechanisms were found unsatisfactory for this application as the backward movement caused by the click settling back into a ratchet tooth would have caused the carriage to draw away slightly from its stop and leave the ball drive off center on the integrator disk. This movement being variable could not be corrected by stop adjustment. A precisely made overdrive ball clutch (directly under time indicator, *Fig.* 3) satisfied the requirements as its slight settle-back was practically constant and could be accurately compensated.

A secondary pin on the wind knob disk sweeps around the inside of the sickle-shaped portion of the reset lever during the winding operation, causing it to move downward and disengage the indicator drum from the integrating mechanism. Thus freed, the drums return to their starting point under the influence of spring-loaded follower rollers which engage a single stationary heart cam within the drums. Upon release the winding knob snaps back to its initial position causing re-engagement of the drums.

Preliminary Adjustment Not Indicated

As previously explained, the sextant knob is rotated to adjust the sextant to the star altitude. The integrating disk also will rotate because it is geared to the knob. However, since the ball drive was centered on the disk in the winding operation, the drive ratio between the disk and the cylinder is zero and no motion is transmitted through the integrator to the indicator drums. Therefore the preliminary adjusting movement does not enter into the mechanically computed average.

When the starting button, *Fig.* 2 is depressed, it causes a sweep wire (not shown) to move out of engagement with the balance wheel, freeing it and at the same time giving it a starting impulse. The timing escapement, *Fig.* 3, thus set in operation, permits the carriage to move on its guide rails under the influence of the drive springs and the

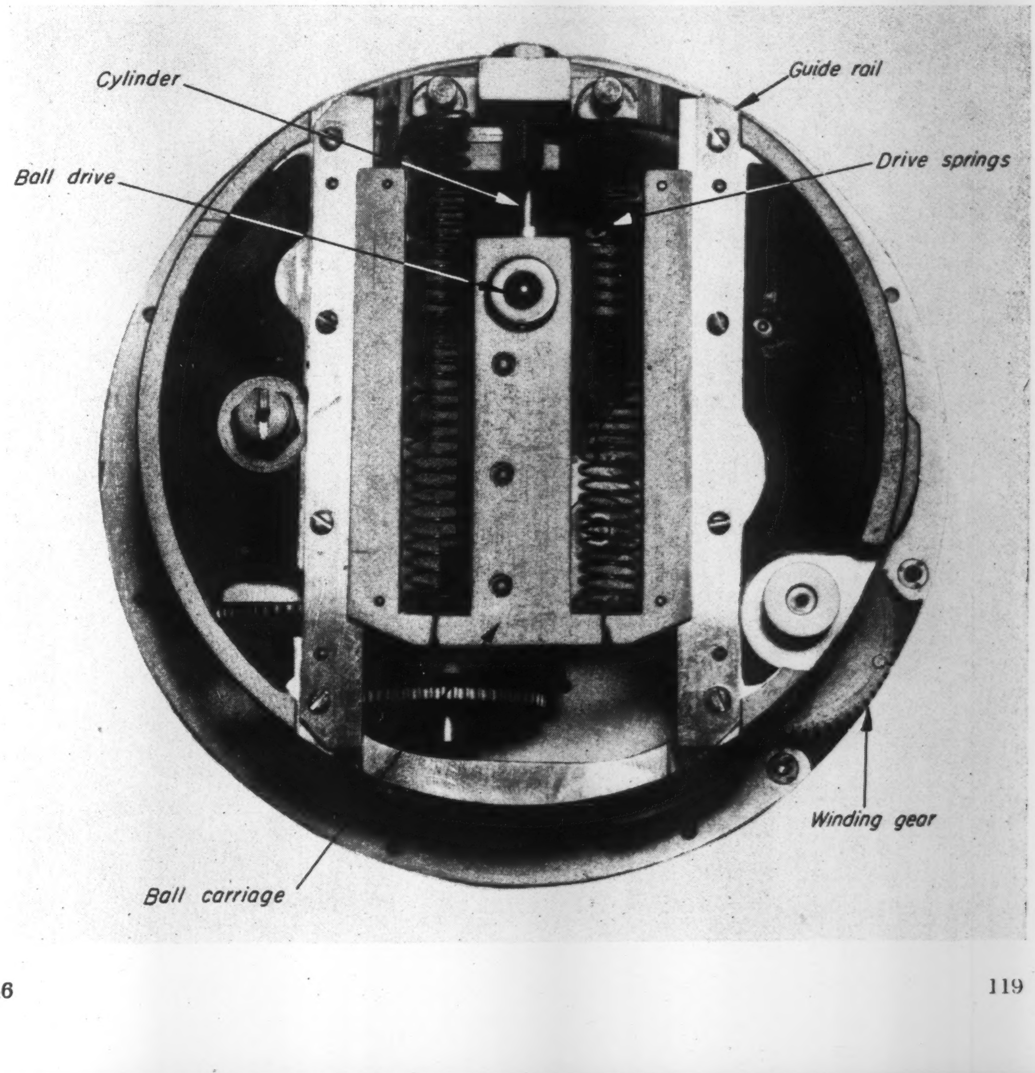


Fig. 4—Ball unit of integrator shows design of carriage, helical drive springs and the guide rails

ball drive moves radially from the center of the disk at a constant rate.

By continual adjustment of the sextant knob the star is kept in alignment as accurately as possible. Knob movement is transmitted to the indicator drums through the constantly increasing ratio between the disk and cylinder. The indicator drum bearing the index mark is geared to the cylinder at a ratio of 1:1, so chosen as to give sufficient movement for accurate setting. However, the angular movement built up during an observation may carry the index mark out of sight beyond the limits of the viewing window.

Therefore a second slow-moving drum, which has a ratio of approximately 1:4 with the cylinder, is required to show the direction in which the cylinder is to be returned to its initial position. The drum gearing may be traced readily in *Fig.* 3. Since this secondary drum never moves as much as 180 degrees in normal operation, the two halves of its periphery are inscribed with opposed arrows to point the direction for the return of the index mark.

Average Readily Obtained

As has been mentioned, average elevation is obtained at the conclusion of the observation by turning the sextant knob so that the index mark is brought back to its starting point (in alignment with the line on the window) in the direction indicated by the arrows. The sextant counter then indicates the average altitude.

One of the vitally important features of this instrument, not found in other averagers is, as has been mentioned, the fact that observations can be terminated by releasing the starting button at any time within the two-minute interval. Releasing the starting button obviously stops the timing mechanism and carriage. Therefore if the sextant knob is unintentionally turned after the button is released, or after the expiration of two minutes, there will be no effect whatever on the average because the integrator ratio remains fixed.

Consequently, when the drums and cylinder are brought back to the starting position, the disk first turns back through the same angle it was advanced after the button was released and the rest of its action produces the averaging action previously described.

The time dial, *Fig.* 2, is graduated in 60 divisions, each one of which represents two seconds in order that the indicated time shall be half the time of observation. Therefore when this indicated time is added to the starting time it gives, of course, the time at which the mean altitude has occured.

Light for illumination is distributed to the time dial and indicator drums from a single dial light, *Fig.* 2, by means of a Lucite plate directly under the cover. Illumination of the altitude counter is led to it from the same dial light by means of a Lucite conductor in a metal sheathing. Current is supplied by three dry cells contained in a metal tube, carried by the observer, and connected to the sextant by means of a cable which is equipped with a detachable plug.

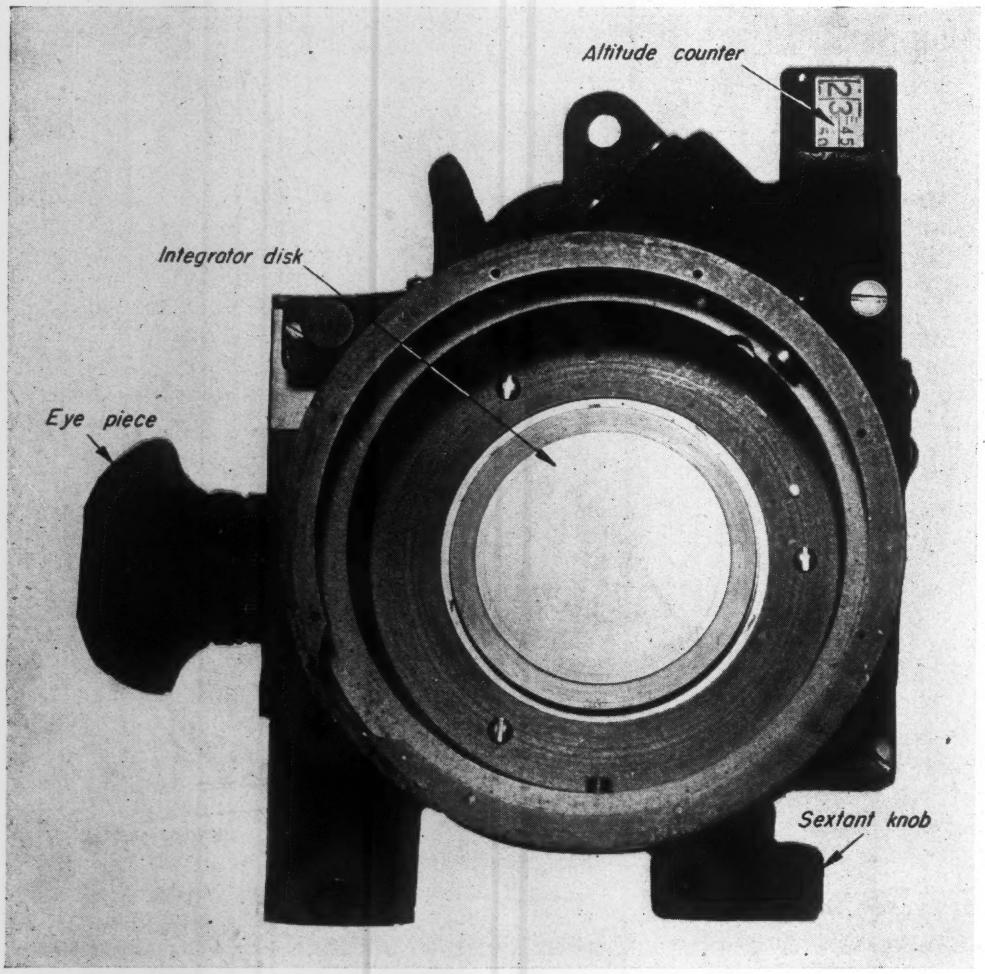
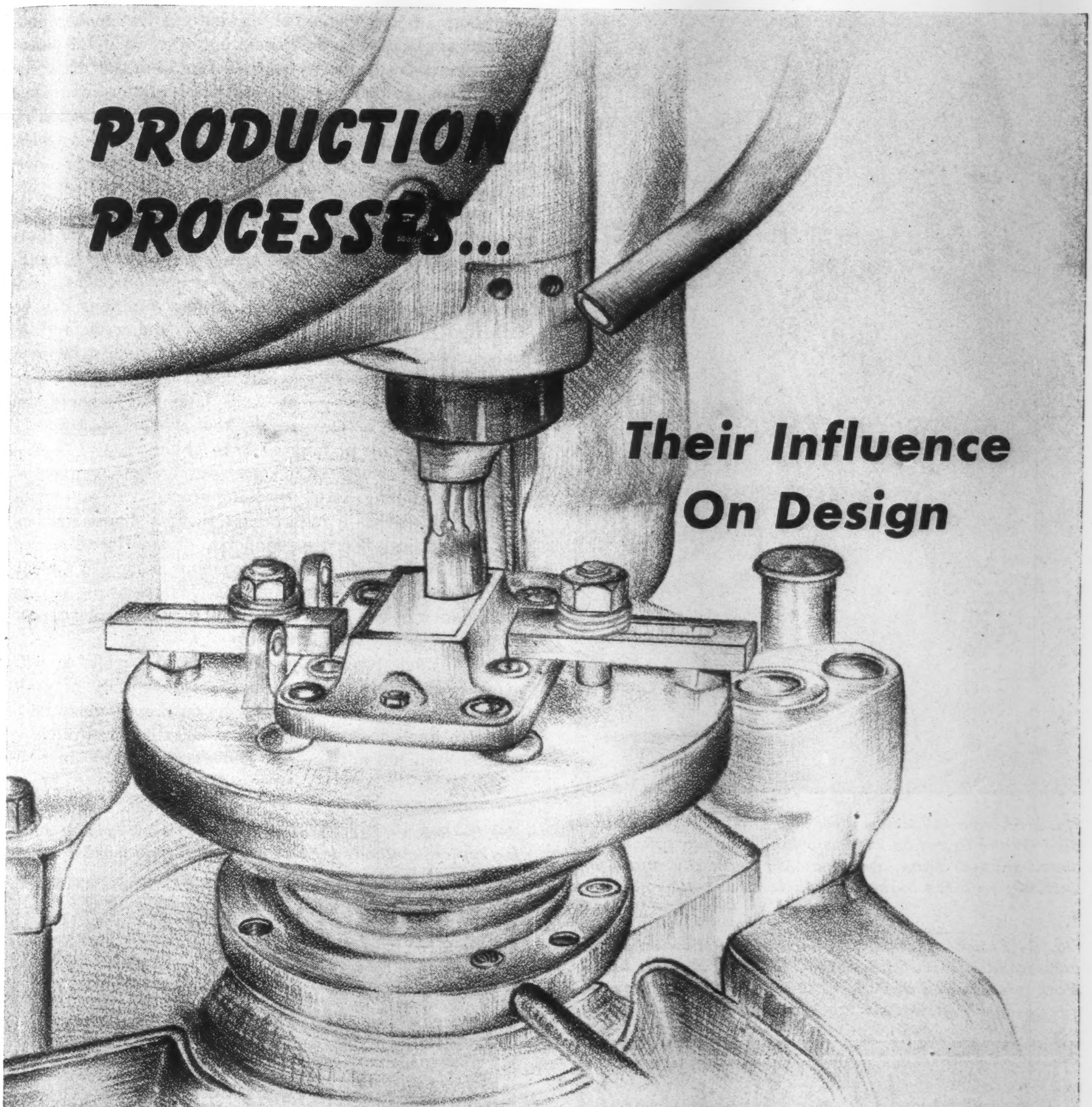


Fig. 5—Housing with bulk of mechanism removed shows integrator disk which is used in conjunction with ball drive

PRODUCTION PROCESSES...

Their Influence On Design



Part IX—Gear-Shaper Generating

By Roger W. Bolz
Assistant Editor, Machine Design

ALTHOUGH gear shaper machining is generally considered a special-purpose process primarily adapted to the generating of gears and gear teeth, its overall versatility and ability to produce an ever increasing variety of machine parts, *Fig.* 1, places it among the important mass-production processes. The generation of eccentric, gap, metering, and special type gears by this method, as well as ratchets, clutches, cams, multiple cams, splines, and unusual shapes, presents not only a fascinating but also a highly practical study for machine designers interested in lowering production costs of such special machine parts.

Of great importance in connection with the application of the gear shaper generating principle is the cutting tool used and its method of

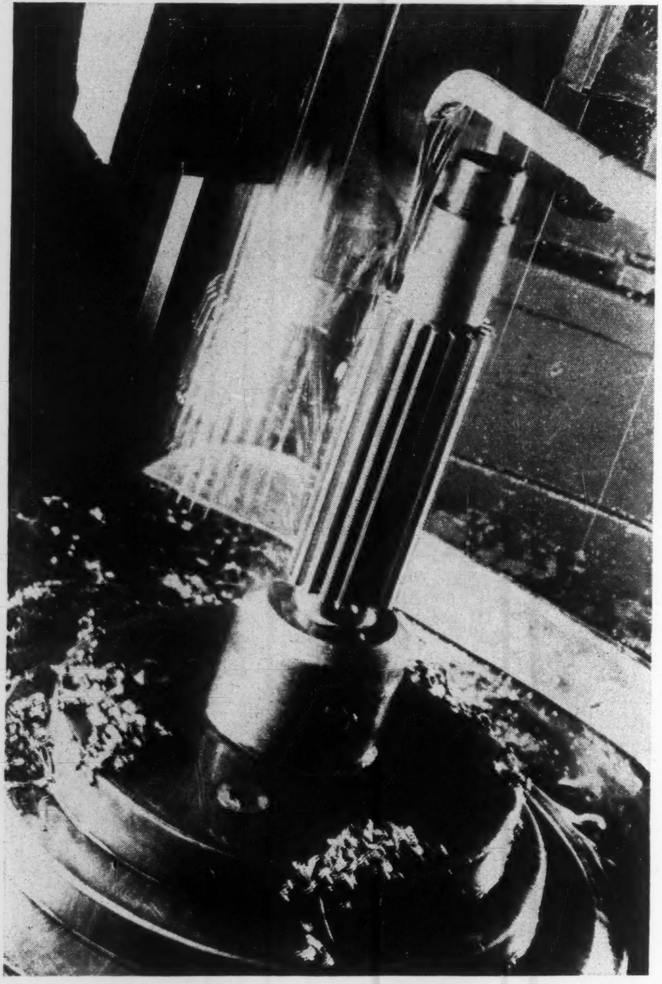


Fig. 1—Above—Close-up view of a number 6 type Fellows gear shaper in action cutting a long involute spline. The pinion-shaped cutter, reciprocating vertically, turns continuously with the blank in predetermined, timed relation

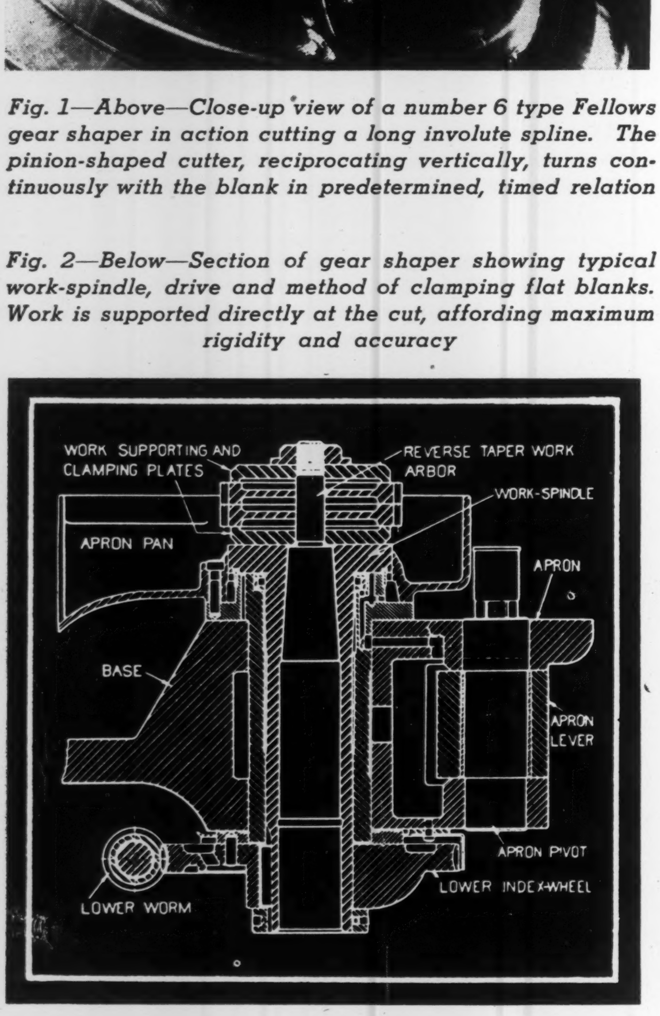


Fig. 2—Below—Section of gear shaper showing typical work-spindle, drive and method of clamping flat blanks. Work is supported directly at the cut, affording maximum rigidity and accuracy

WORK SUPPORTING AND CLAMPING PLATES
REVERSE TAPER WORK ARBOR
WORK-SPINDLE
APRON PAN
APRON
BASE
APRON LEVER
APRON PIVOT
LOWER INDEX-WHEEL
LOWER WORM

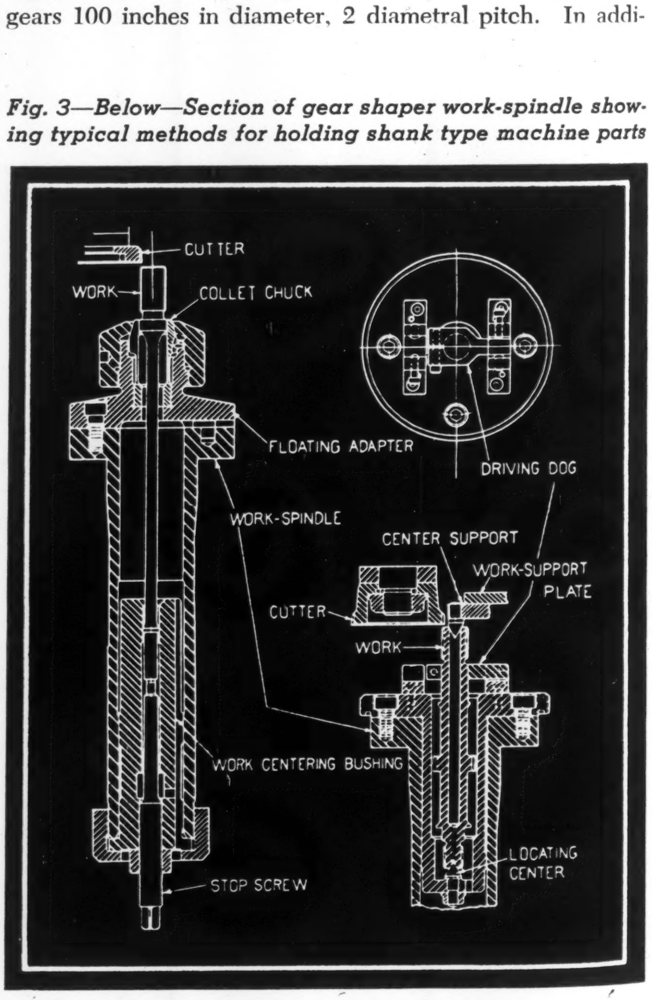
operation. Reciprocation of the cutting tool makes possible its application to the generating of external and internal surfaces by properly controlled movements of workpiece or tool, or both, and also permits operating the tool in comparatively narrow recesses. It is this combination of tool reciprocation with controlled generating motion which makes the "Fellows Method" so universal in its application to the production of unusual machine parts.

Combining the basic principles of both the common engine lathe and the well known crank shaper, the gear shaper usually allows a selection between several methods of machining, simplifying production problems. Rotational movement as well as position variations can be imparted to the generating tool or to the work and, in some cases, a "conjugate" or mated surface can be used on the cutting tool to generate a desired shape. Often, combinations of movements and "conjugate" shapes can be employed to achieve results that would otherwise be extremely difficult or impossible to obtain.

Generation, as utilized to some degree in other processes such as broaching, screw machining and Swiss automatic machining, reaches a high degree in gear-shaper machining. In general, it is the production of a surface—curved or straight—by means of the continuous motion of a point, a line, or a form. Generated profiles consisting of any combination of two basic surfaces—curved and plane—can be practically any shape desired.

Ten distinct types of gear shapers are available with many modifications for handling a wide variety of work. These machines are adapted to the cutting of gears ranging from small fine-pitch pinions of 200 diametral pitch, to gears 100 inches in diameter, 2 diametral pitch. In addi-

Fig. 3—Below—Section of gear shaper work-spindle showing typical methods for holding shank type machine parts



CUTTER
WORK
COLLET CHUCK
FLOATING ADAPTER
DRIVING DOG
WORK-SPINDLE
CENTER SUPPORT
WORK-SUPPORT PLATE
CUTTER
WORK
WORK CENTERING BUSHING
LOCATING CENTER
STOP SCREW

tion to the great range of unusual generated forms possible within this size capacity, special fixtures and attachments can be utilized to perform side trimming operations on clutch teeth, intermittent slotting, worm cutting, etc.

Design: A fundamental requirement in the accurate machining of parts is that the work be located or supported from the same surfaces which are used as locating points when the part is assembled. Parts not readily adapted to such support, therefore, require highly specialized fixtures, increasing costs unduly where large volume production is not in order. Ordinarily gear blanks with a central hole are clamped on an arbor with support plates located both beneath and over the work, *Fig.* 2. Support plates are usually designed to be only slightly smaller than the contour of the part to lend support directly at the cut. Shank or shaft parts require other means such as clamp sleeves or centers, *Fig.* 3. In producing large quantities of parts with odd contours, magazine fixtures and automatic arrangements are used.

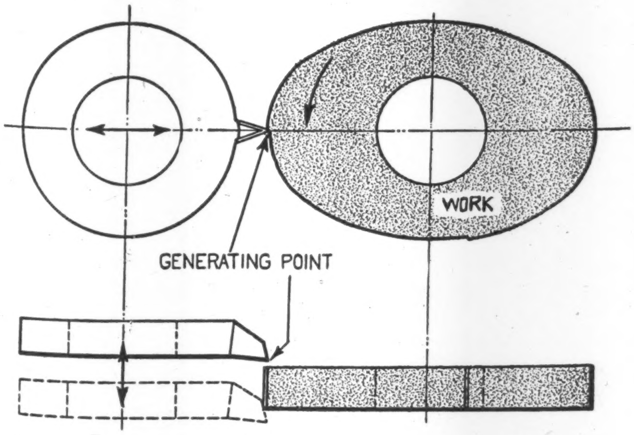
Simple Generating: Two simple motions imparted to a single-point tool, *Fig.* 4, with constant rotation of the work generate a simple shape, the exact contour depending upon the relation of tool movement (to and from the work) to the work rotation. By moving the reciprocating generating point in proper relation to the work center a constant-rise cam contour is obtained, *Fig.* 5.

Generating Surface is Used

For rapid machining, a surface rather than a point is generally used. A simple irregular cam produced by such a cutter under the required radial control is shown in *Fig.* 6. Setting the cutter at an angle to the work, however, accomplishes either external or internal conical surfaces, *Fig.* 7, or gears. By locating cutting and work spindles at right angles to each other, throated or hourglass shapes can be produced, *Fig.* 8.

"Conjugate" Generating: To apply the molding-generating principle, both cutter and work must have pitch-line movement. This can be either two pitch circles rolling together as with the cutting of internal and external gears, *Fig.* 9, a combination of a pitch circle and a pitch-line movement as in cutting a rack, or the pitch-line movement of irregular shapes. Using fixed work and cutter centers, the cam shown in *Fig.* 6 can be generated by a conjugate-

Fig. 4—Below—Layout depicting the generating of an elliptical surface by means of a single-point tool



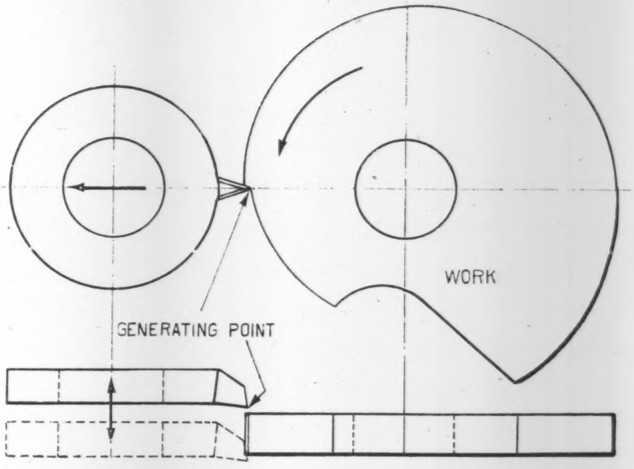


Fig. 5—Above—Constant-rise cam generated by single-point tool with properly controlled center distance

Fig. 6—Below—Using a disk type generating cutter, an irregular cam such as this can be produced at greatly reduced machining time over that needed with a single-point tool such as that shown in Fig. 5

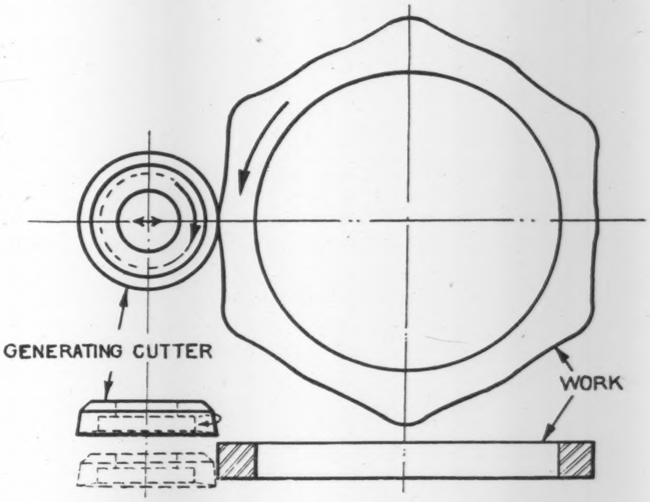
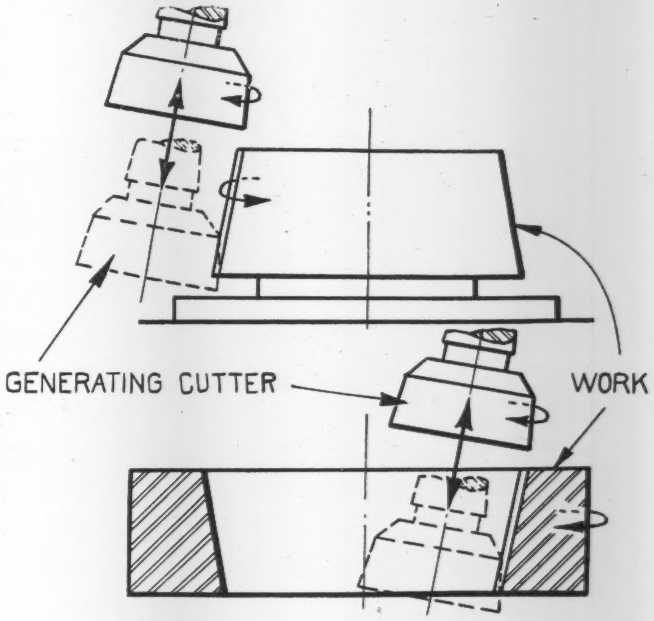


Fig. 7—Below—Conical surfaces or gears are produced by positioning the reciprocating cutter at the desired angle



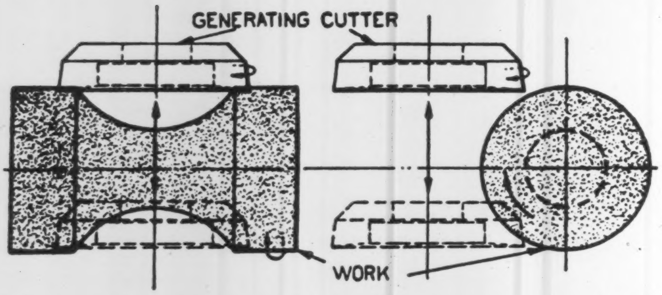


Fig. 8—Above—Throated or hourglass shapes are easily produced by locating the work and cutter spindles in offset positions at right angles

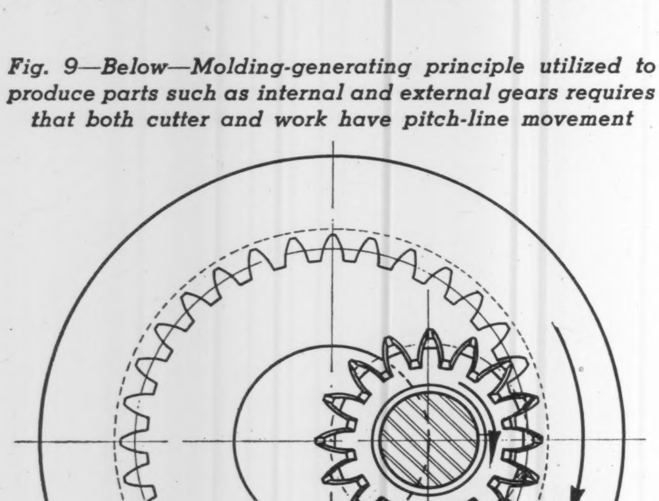
shaped cutter, *Fig.* 10, with definite relationship between the rotation of both work and cutter. In this case the cutter makes six revolutions to each one of the work.

Irregular shapes such as the special pawls shown in *Fig.* 11 are easily generated, two cutters as indicated being used in each case. Such parts can be produced at a rapid rate, accurately, and with a high degree of finish.

Warped surfaces similar to those of the teeth of a helical gear can be produced on a machine which not only has controlled relationship of rotation between work and cutter but also imparts a controlled twisting motion to the cutter spindle.

"OFFSET-CONJUGATE" GENERATING: When the cutter and work are of the same general shape, when one member—cutter or work—is external and the other internal, or when both members rotate at a one-to-one ratio, the generating is termed "offset". Some simple hole shapes produced by this method are shown in *Fig.* 12. Both work and cutter are rotated in the same direction at a one-to-one ratio, one revolution completing a round as well as a three-lobed hole. The size of the hole is controlled by the amount of offset. Radius produced in a square hole, *Fig.* 13, is equal to the amount of offset and where such a large radius is objectionable it must be removed with a special tool or another method used. Sharpest corners possible are produced with a three-cornered cutter, *Fig.* 14, with the "rolling" circle used in generating passing through the corner. Multiple holes of such shapes may also be produced simultaneously.

Fig. 9—Below—Molding-generating principle utilized to produce parts such as internal and external gears requires that both cutter and work have pitch-line movement



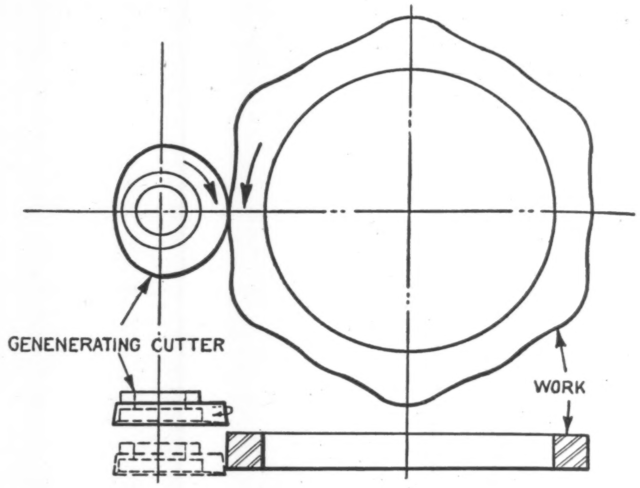
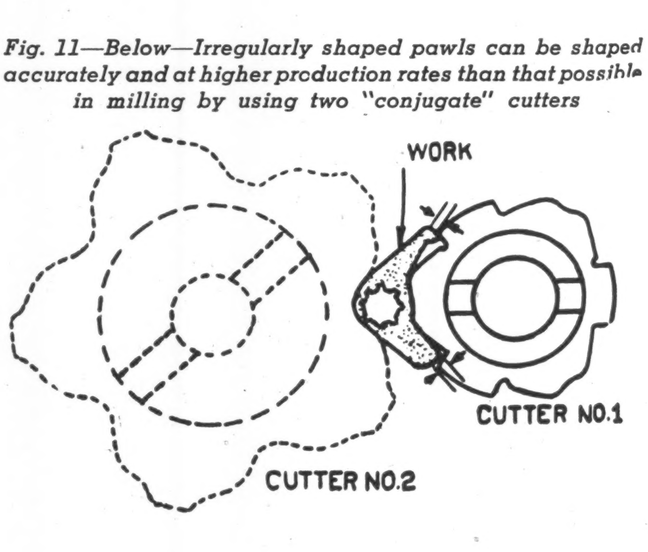


Fig. 10—Above—Using molding-generating principle and a "conjugate" cutter, the cam shown in Fig. 6 can be generated without radial movement of either work or cutter

Fig. 11—Below—Irregularly shaped pawls can be shaped accurately and at higher production rates than that possible in milling by using two "conjugate" cutters



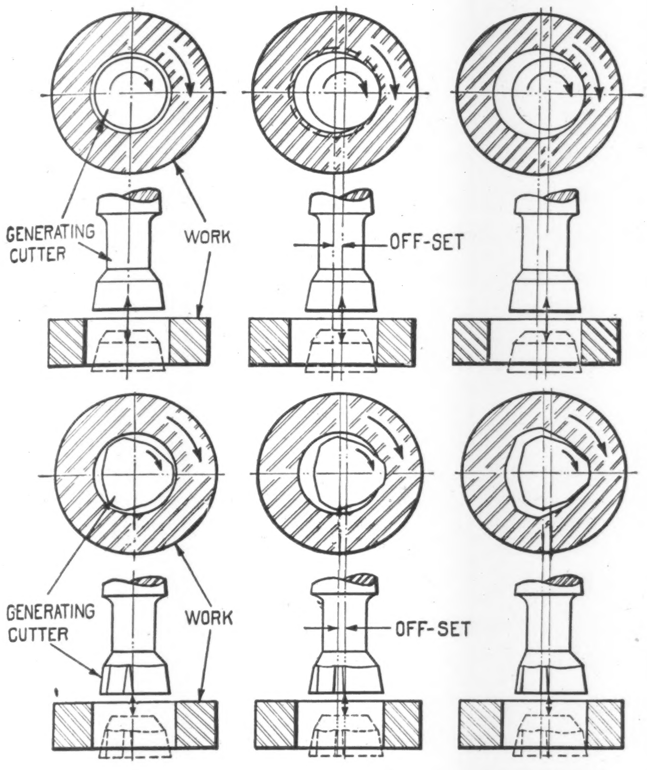


Fig. 12—Above—Round or three-lobed hole generated in one revolution by "offset" of the cutter

"Off-Center-Conjugate" Generating: In certain cases it is advantageous to locate work off-center in the fixture, especially to simplify cutter design. This is exemplified in *Fig.* 15. Rough formed by milling, this brake cam is finished in one revolution.

A unique application is shown in *Fig.* 16 where one set of teeth on a segment gear is concentric with the hole, and another set is on a cam surface. The concentric segment presents no problem but the cam section requires a special type fixture. To produce noncircular gears, three motions are usually required—a master segment gear and rack being necessary to impart the proper movement to the work.

"Interrupted-Conjugate" Generating: This method applies to unusual parts where the progression of cutting must be interrupted. The refrigerator pump piston, *Fig.* 17, is typical of a part successfully machined by an interrupted cutter. Various types of tooth forms can be generated on the same part, *Fig.* 18, by one cutter. A stack of such combination segment gear and ratchet parts for cash registers are produced in a single operation.

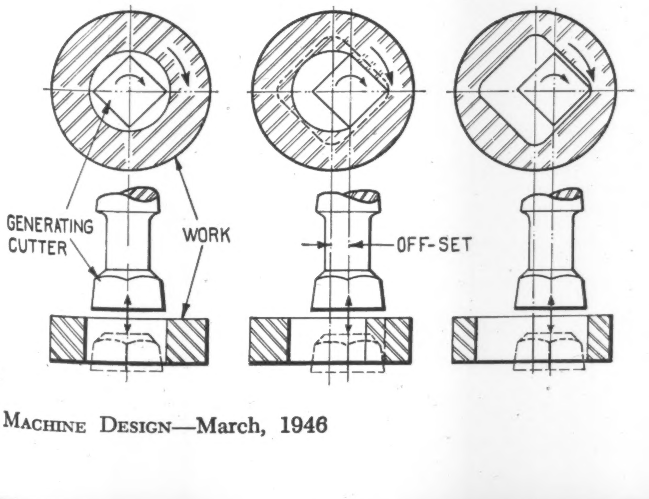
A change in position of cutter or work can be used to allow finishing of different or closely related portions of a complicated part. Twin cutters are used to provide for rough and finish cutting of accurate holes, *Fig.* 19. Table and fixture in this instance are geared in sequence with the cutter, the table rising to allow finishing of the hole by means of the upper portion of the cutter without disturbing the cycle.

Progressive cam cutting is achieved in a similar manner, *Fig.* 20. Here six individual cam lobes are generated by a single cutter, the work being moved to bring the various cam lobes into position. Cam contours are identical and equally spaced but are not in consecutive order. The cutter is made with six generating projections spaced to produce each lobe in proper relationship to a keyway.

Gap-type cutters, *Fig.* 18, also can be designed to have roughing teeth (in one or two stages) and finishing teeth. By this means exceptionally accurate tooth forms can be produced especially when the softer nonferrous materials such as brass are used.

An unusual example of "interrupted" generating is shown in *Fig.* 21. These pump metering gears have a

Fig. 13—Below—Square hole produced with square cutter by "offset" method has a corner radius equal to the offset



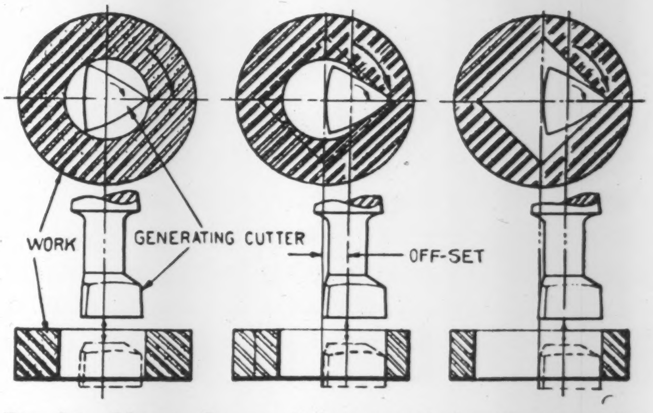
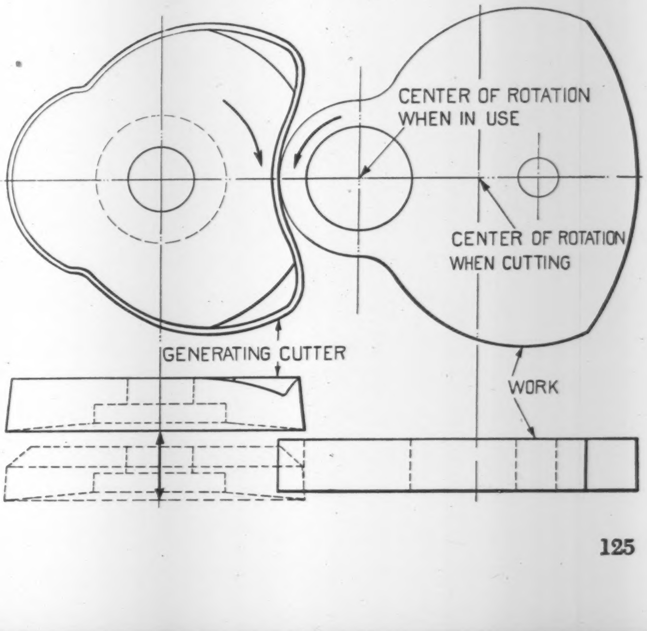


Fig. 14—Above—Square hole generated with triangular cutter by "offset" method with corner radius approaching that of the cutting edge of the tool

Fig. 15—Below—To simplify cutter design, unusual and complicated shapes are located in an "off-center" position


CENTER OF ROTATION WHEN IN USE
CENTER OF ROTATION WHEN CUTTING
GENERATING CUTTER
WORK

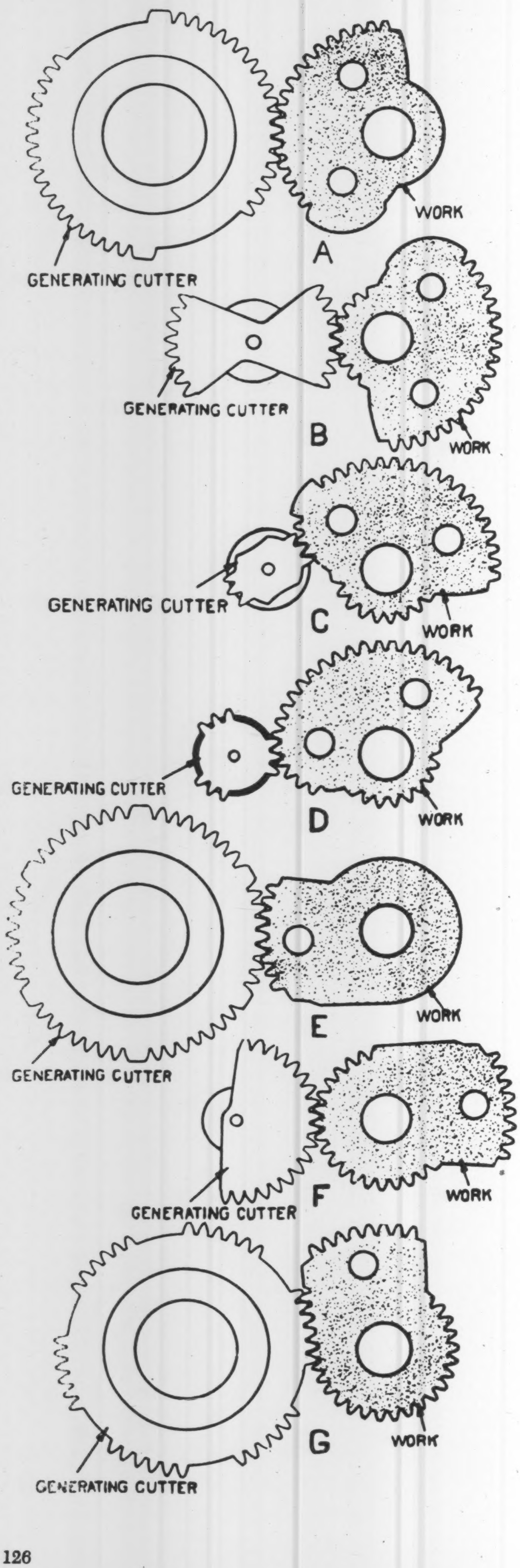


Fig. 16—Left—Plan showing the sequence of operations used to generate a "two-lobed" segment gear. Two operations are performed on each segment—disking to blank size and cutting the gear teeth

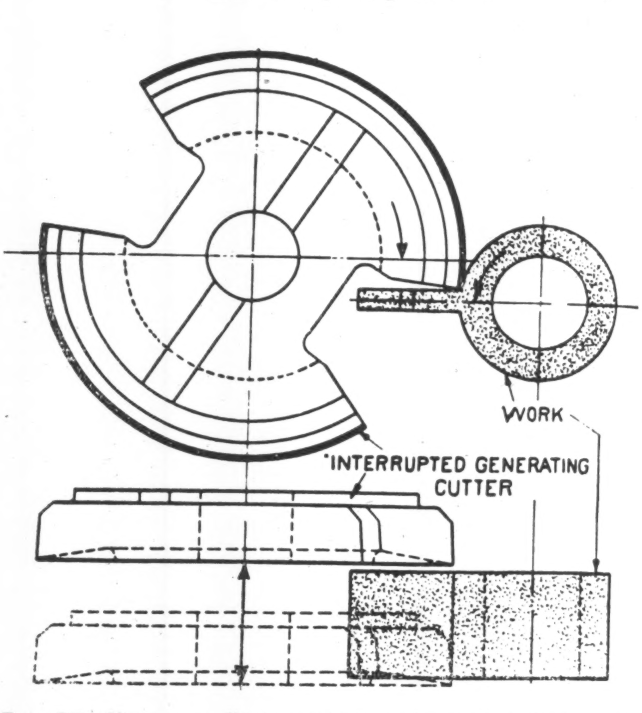


Fig. 17—Using an "interrupted-conjugate" cutter, a refrigerator pump piston is finished in two cuts around

combination of concentric, eccentric and rack-tooth forms. Seven separate operations are necessary to complete the two parts, four for the one and three for the other. All teeth must have accurate mating conjugate action inasmuch as the pair of metering gears operate on fixed centers.

"DESCRIBING" GENERATING: This form of generating reverts to the original conception of producing or generating a surface by means of a point and differs from conjugate generating in that only one member has pitch-line movement. The principle is especially applicable to cutting of clutch faces and similar work where helicoidal surfaces are required. Airplane engine jaw-tooth clutch part, *Fig.* 22, illustrates this type of generation. Utilizing substantially a single rounded point of one tooth on the cutting tool as the work is rotated, the cutter advances into the work, generating the correct form and at full depth finishing the form. Such work is located at a slight angle to allow clearance for easy withdrawal of the cutter.

Design Possibilities are Unlimited

As can be seen readily from the general character of the great variety of machine parts illustrated, few are produced with standard machine fixtures and tooling. However, a multitude of special attachments for the various models are available and consultation with the manufacturer while unique or special parts are in the design stage will assure minimum costs and successful production.

MATERIALS: Suitability or machinability of various materials with this process parallels somewhat that for broaching*. Four cutting speeds are normally available in 111,

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* See "Part I—Broaching" of this series, MACHINE DESIGN, July 1945.

184, 270, and 342 cutter strokes per minute. The slower speeds are used with long strokes and also for the harder materials. Considering high machinability stock only‡, proper cutting fluid and a maximum feed stroke of one inch, cast iron can be cut at a speed of 60 fpm, mild steel at 90 fpm, high-carbon steel at 65 fpm, tool steel at 70 fpm, chrome-nickel steel at 50 fpm, soft brass at 100 fpm, and aluminum at 200 fpm. These speeds are reduced about 10 per cent for each additional inch of cutter stroke. On standard machines the usual number of feed strokes available per revolution of the cutter are 720, 900, 1080, 1260, 1440, and 1620. A number 7 machine, limited to small work, operates at much higher speeds.

Tolerances: To maintain accuracy on parts which cannot be supported solidly, the finest and consequently slowest feeds must be used. More than one revolution of the work is often required where accuracy and quality must be of the highest. Also, the accuracy of the machined blank is of primary importance, since the final accuracy of the part is governed to a large extent by the blank conformance as well as the method used in holding it. Naturally, demand for closer limits than those actually needed to suit the requirements increases considerably the cost of any part.

Manufacturing Limits Set by Requirements

A study of manufacturing limits set and found to be practical by various industries reveals that they vary considerably, depending primarily upon the nature of the part to be produced and its application. Bore diameter, for instance, on parts with holes is controlled somewhat by the amount of runout allowed. On circular parts, the limit on hole variation is set at about one-half the total amount of runout allowable on the finished part. Blanks can be produced for the gear shaper within a total variation of 0.0002-inch on bore diameters of 0.125 inch and over.

Inasmuch as practically all blanks, except those mounted on centers, are held by the faces, these must be square with the bore or bores. Face runout is limited to a maximum of 0.0005-inch on "precision" work, and to 0.001-inch for diameters up to 20 inches with 0.003-inch permissible on

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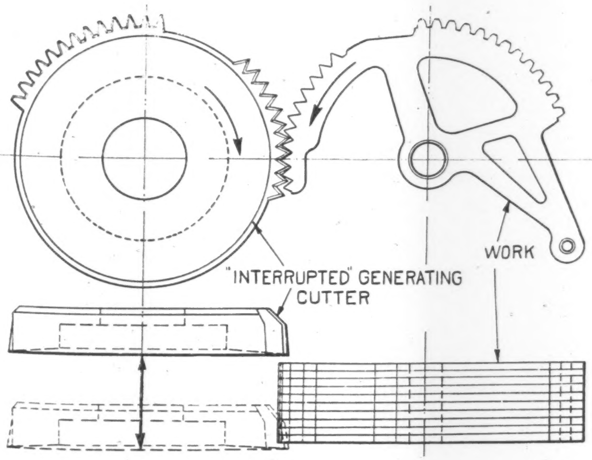
‡ See "Part III—Automatic Screw Machining" of this series, Machine Design, September 1945.

Fig. 18—Below—Both ratchet and involute gear teeth are generated on cash register segment gear by one "interrupted-conjugate" cutter



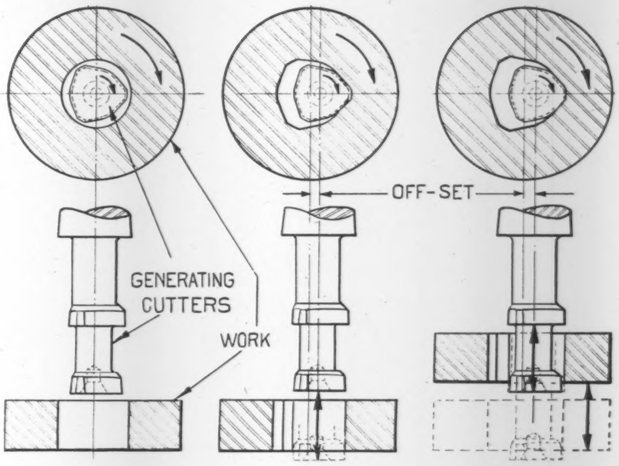


Fig. 19—Above—Twin cutters can be used to rough and finish machine highly accurate holes by elevation of the work table to position the part

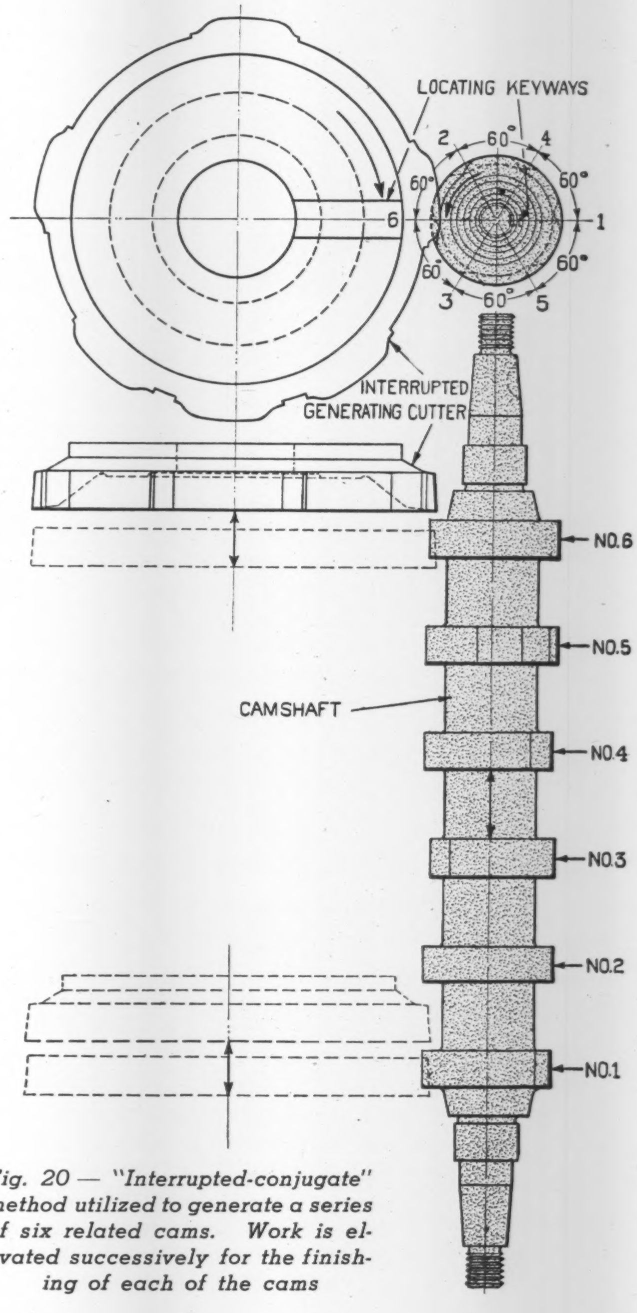
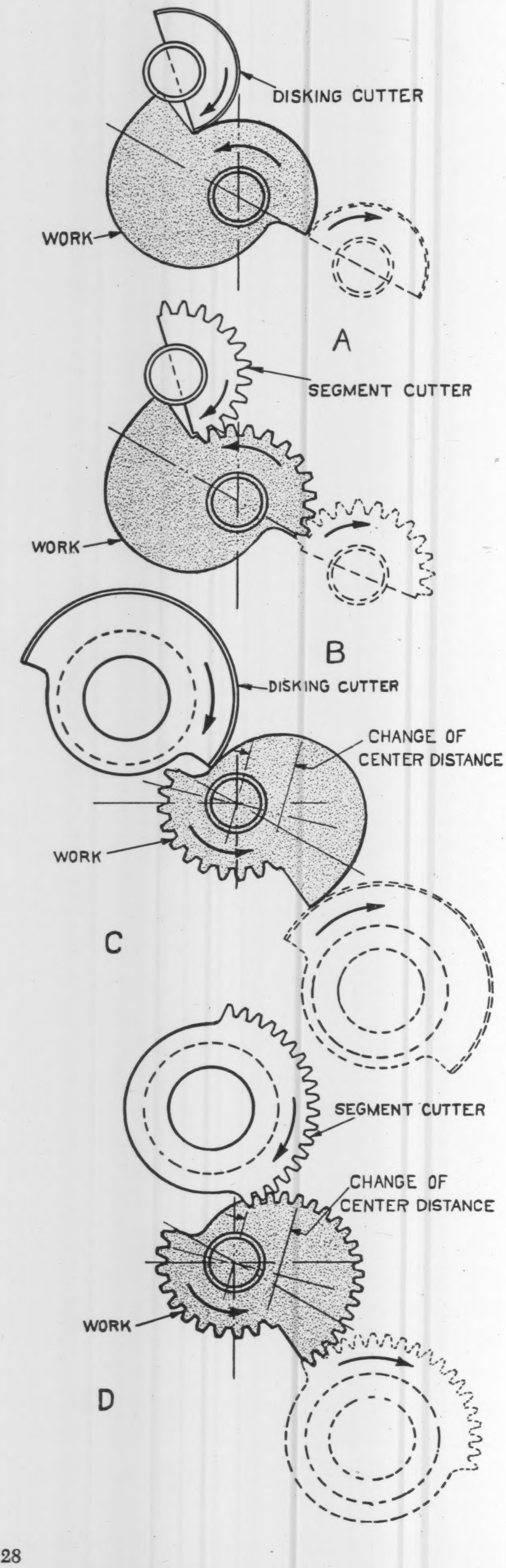


Fig. 20 — "Interrupted-conjugate" method utilized to generate a series of six related cams. Work is elevated successively for the finishing of each of the cams

Fig. 21—Below—Metering pump gears produced by "interrupted" cutters. Concentric, eccentric and rack teeth on these unusual gears are generated in seven operations


DISKING CUTTER
WORK
A
SEGMENT CUTTER
WORK
B
DISKING CUTTER
CHANGE OF CENTER DISTANCE
WORK
C
SEGMENT CUTTER
CHANGE OF CENTER DISTANCE
WORK
D

diameters over 20 inches where general "commercial" work is concerned.

Positioning of various cams in relation to each other, *Fig.* 20, can be held within 0.001-inch for alignment. Also, the radii of cams can be held to a maximum variation of 0.001-inch.

Limits held on ordinary fine-pitch gears in general production on standard or special gear shapers give the best indication of the accuracy which may be expected in the manufacture of the great variety of parts along the lines of those illustrated throughout this article. Gears for "commercial" or ordinary machines are regularly held to a total composite error of 0.006-inch for class 1, 0.004-inch for class 2, or 0.002-inch for class 3, depending mainly upon the machine requirements. Total tooth-to-tooth composite error for such gears runs 0.002, 0.0015, and 0.001-inch, respectively. "Precision" quality gears of fine pitch for instrument work, however, are held to a total composite error of 0.001-inch for class 1, 0.0005-inch for class 2 and 0.00025-inch for class 3, tooth-to-tooth composite errors being 0.0004, 0.0003 and 0.0002-inch, respectively.

"Precision" accuracy such as that where total composite error is held within 0.00025-inch while accompanying tooth-to-tooth error is 0.0002-inch or less usually requires an extra shaving operation. Consequently, unless the machine requirements necessitate "precision" tolerances, widest possible "commercial" limits are preferable to speed production and assure lowest unit cost.

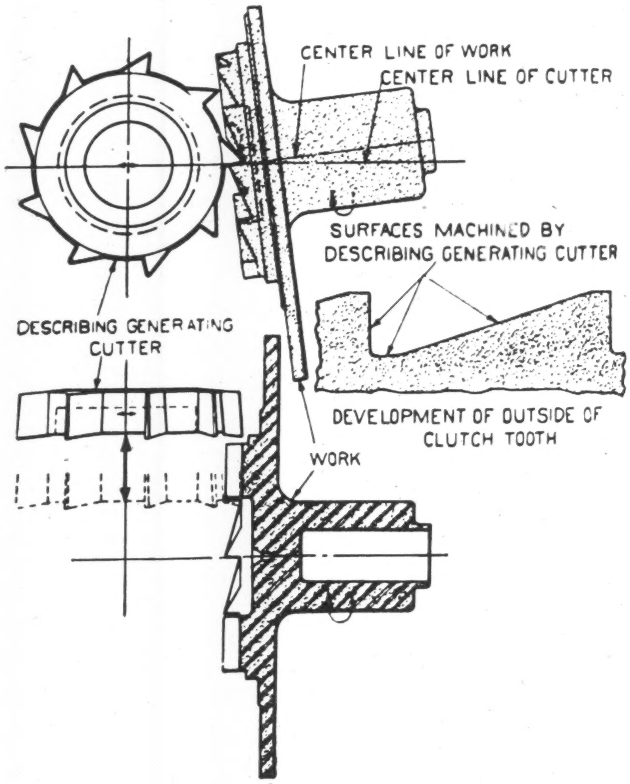
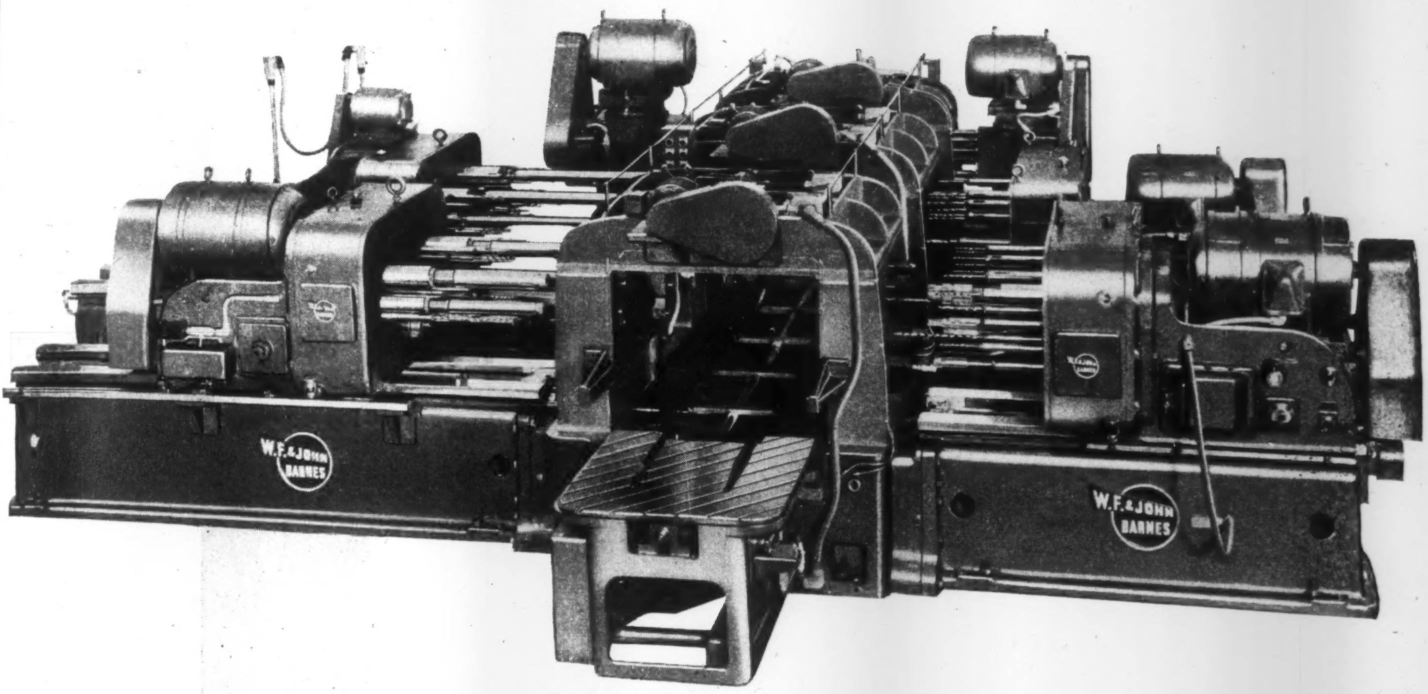

CENTER LINE OF WORK
CENTER LINE OF CUTTER
SURFACES MACHINED BY DESCRIBING GENERATING CUTTER
DESCRIBING GENERATING CUTTER
DEVELOPMENT OF OUTSIDE OF CLUTCH TOOTH
WORK

Fig. 22—"Describing" generation utilizes a virtual single-point cutter to produce a true warped or helicoidal surface such as on the jaw-teeth of this airplane clutch part

The generous collaboration of the Fellows Gear Shaper Co. in the preparation of this article is acknowledged with sincere appreciation.



"PACKAGE" UNITS—For Simplified Design, Low Costs

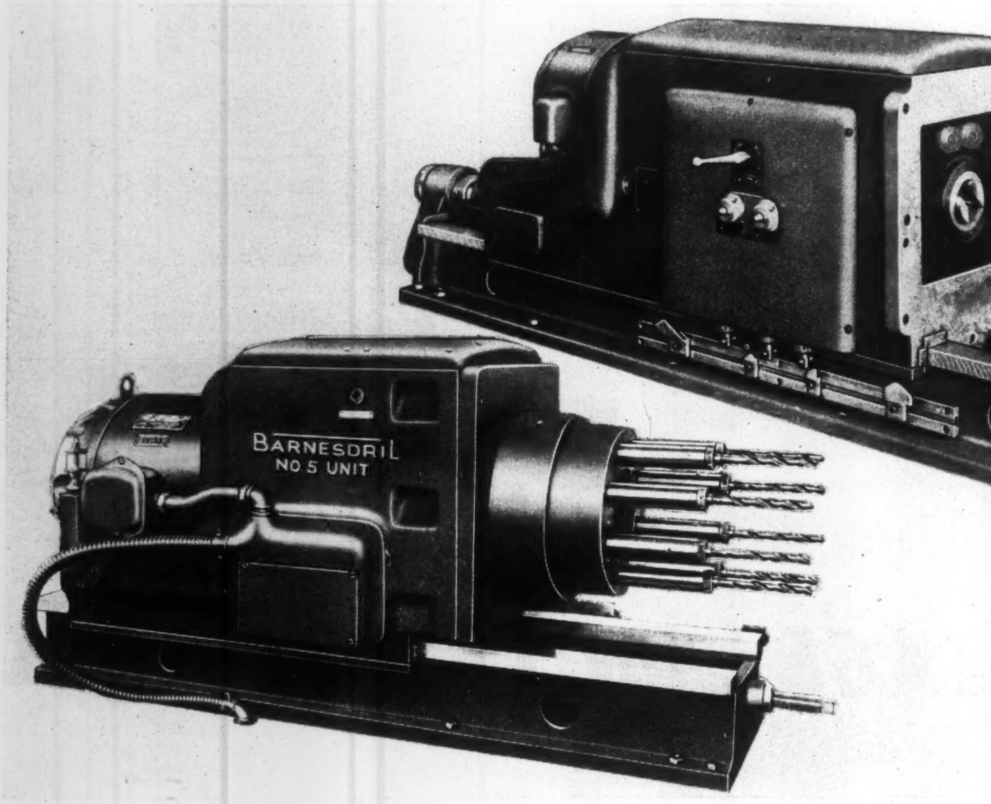
COMMERCIALLY available standard machine units—the complete, self-contained, self-powered "package" type in this instance—make it possible and, in many cases highly economical to develop special-purpose high-production machines. One or any combination of these units can be mounted horizontally, vertically, or at any required angle on a suitable support with either a special or universal type bed. Most units can be adapted for operation simultaneously, in sequence, or in any desired cycle. Controls can be of manual or automatic cycling types.

A wide range of production operations is possible, including turning, milling, hollow milling, single and multiple-spindle drilling, sensitive drilling, boring, counterboring, spotfacing, tapping, grinding, pressing, etc. Units for performing any one type or groups of these operations can be arranged in any combination desired to operate in the sequence necessary for producing any of a great variety of special machine parts.

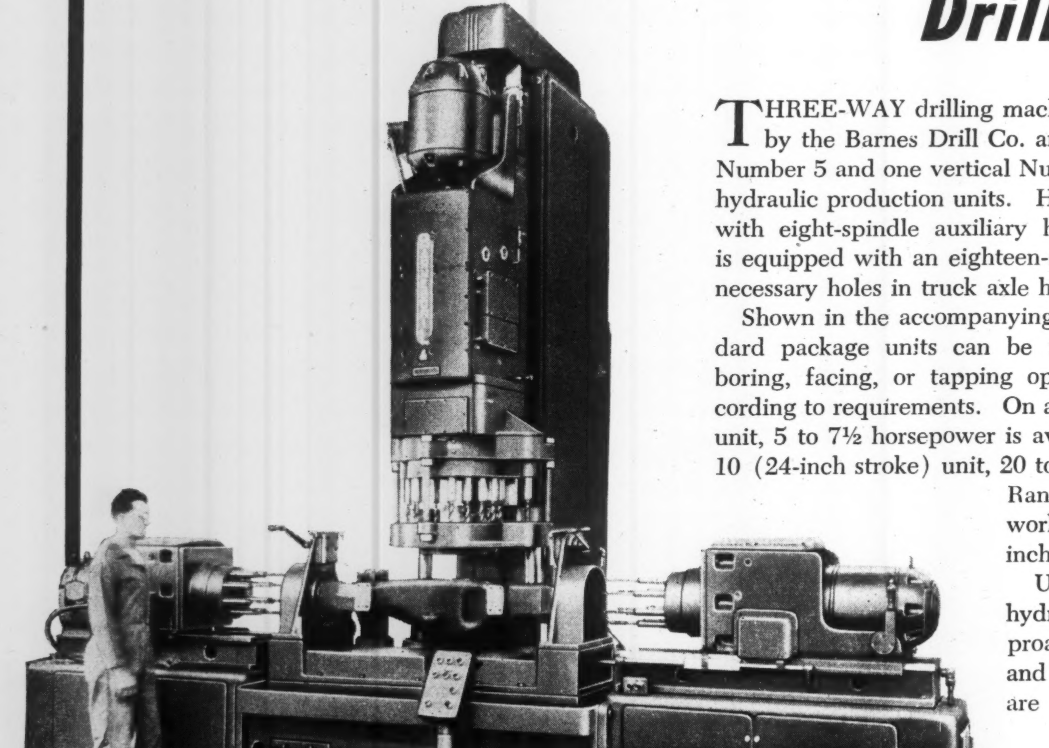
Design of parts for special machines therefore is relatively unhampered by the limitations of standard production machining facilities for performing many of the foregoing production operations. The wide variety of finishing operations available by means of "package" units and the positioning of such units being limited only by the size and intricacy of the part offer great possibilities for the designer. Complete flexibility afforded by package unit arrangements makes it not only possible, but also highly practicable to rearrange the entire layout of a special production setup whenever design requirements so dictate. Thus, machine tools comprised of such groups of units prove economical even on short production runs.

To illustrate some of the many possibilities and to stimulate thought among designers toward further utilization of the package unit principle, this pictorial article is presented. A few of the principal basic units are shown as well as machines on which various mechanisms of this type are used. In most cases, many variations of the basic units are available by merely substituting other head-spindle attachments, etc. The ultimate in useful combinations and duties performed, as can be readily recognized, has certainly not yet been reached. Possible design variations are legion.

"PACKAGE" UNITS



Drilling

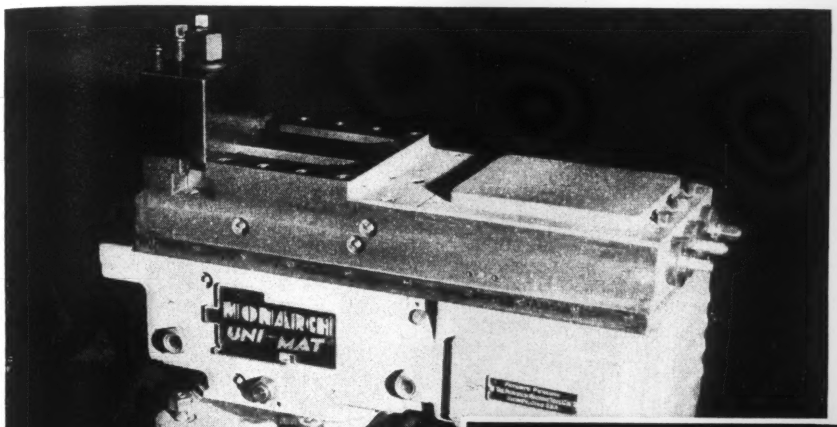


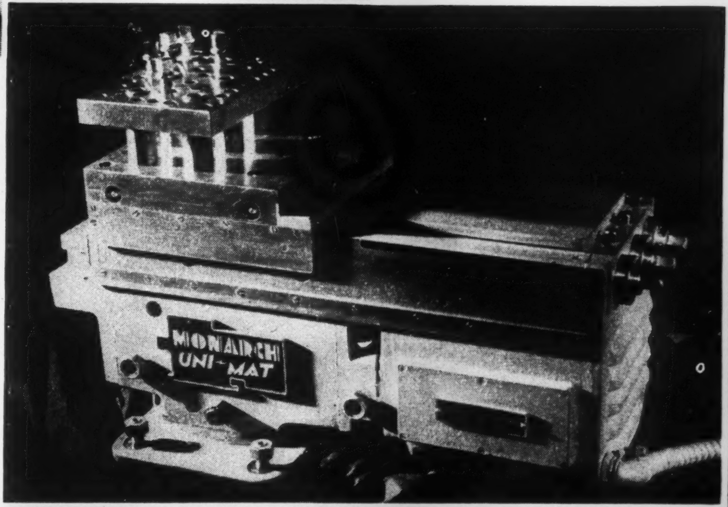
THREE-WAY drilling machine, left, was manufactured by the Barnes Drill Co. and consists of two horizontal Number 5 and one vertical Number 10 standard Barnesdril hydraulic production units. Horizontal units are equipped with eight-spindle auxiliary heads and the vertical unit is equipped with an eighteen-spindle head for drilling the necessary holes in truck axle housings.

Shown in the accompanying enlarged views, these standard package units can be fitted for drilling, reaming, boring, facing, or tapping operations and motorized according to requirements. On a Number 5 (18-inch stroke) unit, 5 to 7½ horsepower is available, while on a Number 10 (24-inch stroke) unit, 20 to 25 horsepower is available. Range of drilling and tapping work runs from ½-inch to 4 inches in diameter.

Units are complete with a hydraulic system for rapid approach, feed (coarse and fine), and quick return. Speed changes are accomplished by means of pick-off gears.

"PACKAGE" UNITS



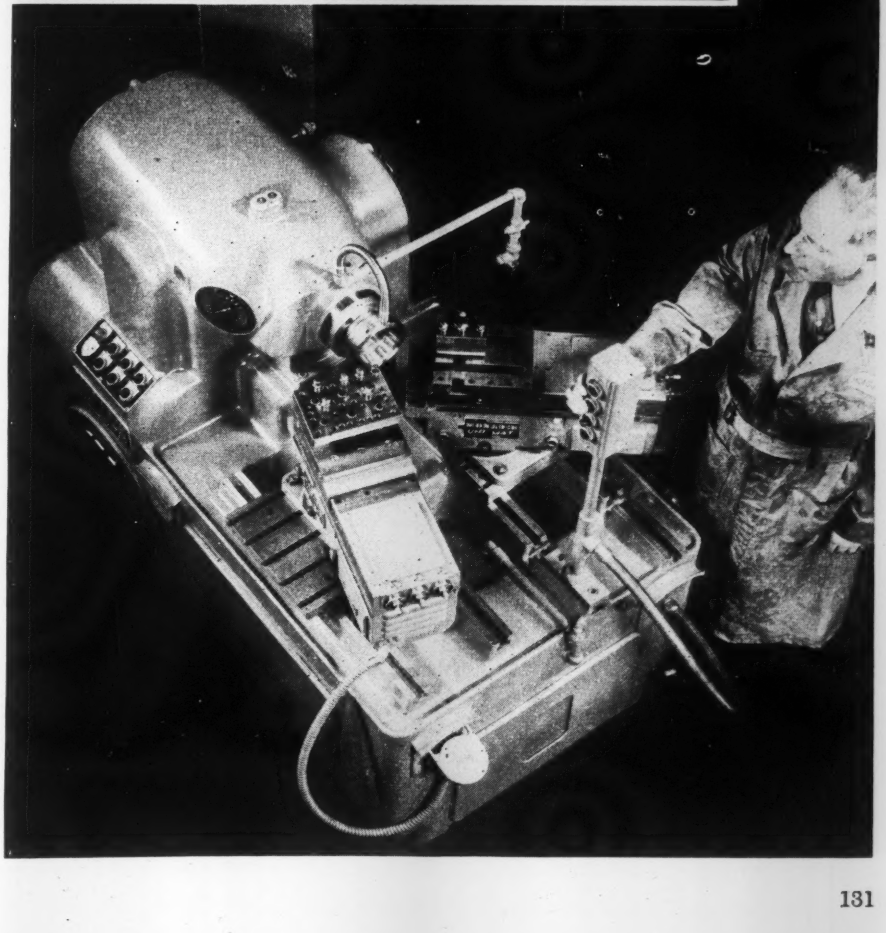


Turning

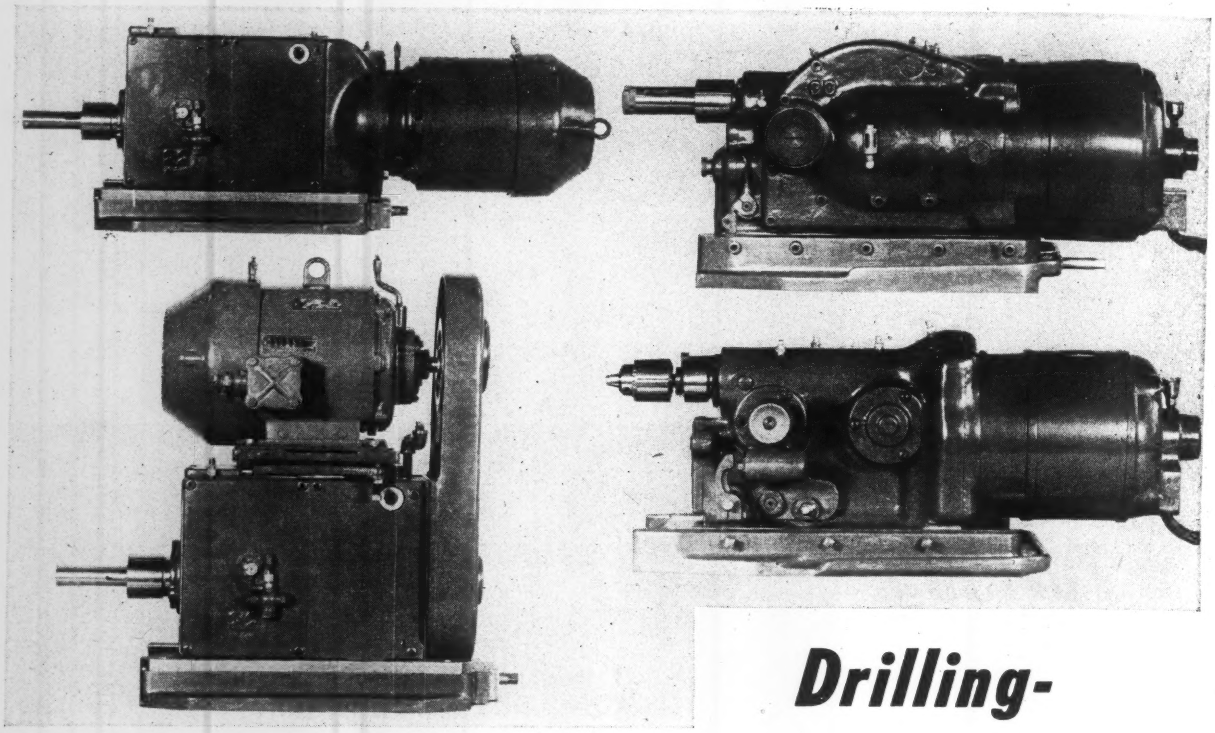
UNUSUAL and rather radical in design compared to the standard type of engine lathe, the turning machine, right below, illustrates the package unit principle applied to turning. Two basic packages: (1) A simplified version of the conventional lathe base and headstock with change gears, motor and associated drive mechanism, and (2) from one to three motorized tool slides—manufatured by Monarch Machine Tool Co.—go to make up the lathe shown.

The tool slides or Uni-Mats, shown in the enlarged views above, are basically individual motor-driven compound rests which can be mounted and grouped about a spindle in any arrangement desired. Equipped with an electrically controlled a-c or d-c motor, the main slide of the device will traverse at 100 inches per minute until automatically slowed to a predetermined feed rate for the remaining part of its total travel of 4 inches. At the end of the feed cycle, the slide will dwell, or immediately revert to 100 inches per minute reverse. Change gears make it possible to attain from ½-inch to 13 inches per minute feed rate.

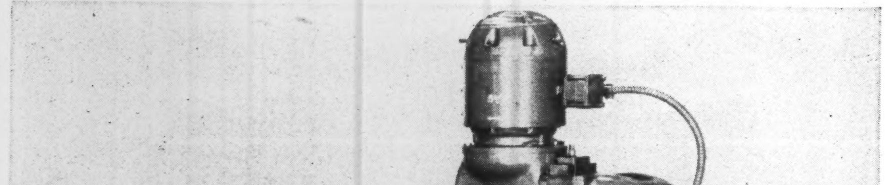
Standard speed ranges for the Uni-Matic heads are: (1) Low speed, 1000 rpm maximum; (2) medium speed, 2000 rpm maximum; (3) high-speed, 3000 rpm maximum. At 3000 rpm, the spindle can be stopped in a little over one second.



"PACKAGE" UNITS



Drilling-Tapping



PROBABLY one of the earliest of package unit manufacturers, Kingsbury Machine Tool Corp. recognized the production machine flexibility achieved only by such unit design. Featuring single and multiple-spindle drilling, milling, and tapping operations, these automatic units, above, are available in nine basic models. Drilling units are available with frictional or positive feed to the spindle and, when arranged for tapping, use a special tapping cam developed to give a feed per revolution corresponding to the lead of the tap used.

The indexing machine, left, utilizing these units, perform various operations on a small casting for refrigerators. At station 1, a vertical Model 30 drilling unit end-mills a boss; at station 2, a vertical Model 30 unit end-mills an irregular face; at station 3, a horizontal Model 12 unit drills six 17/64-inch holes and simultaneously a vertical Model 18 unit drills a ¼-inch hole; at station 4, a horizontal Model 18 unit drills a partial 7/32-inch hole and a vertical model 18 unit countersinks the previously drilled ¼-inch hole; at station 5, a vertical unit counterbores the 17/64-in. holes.

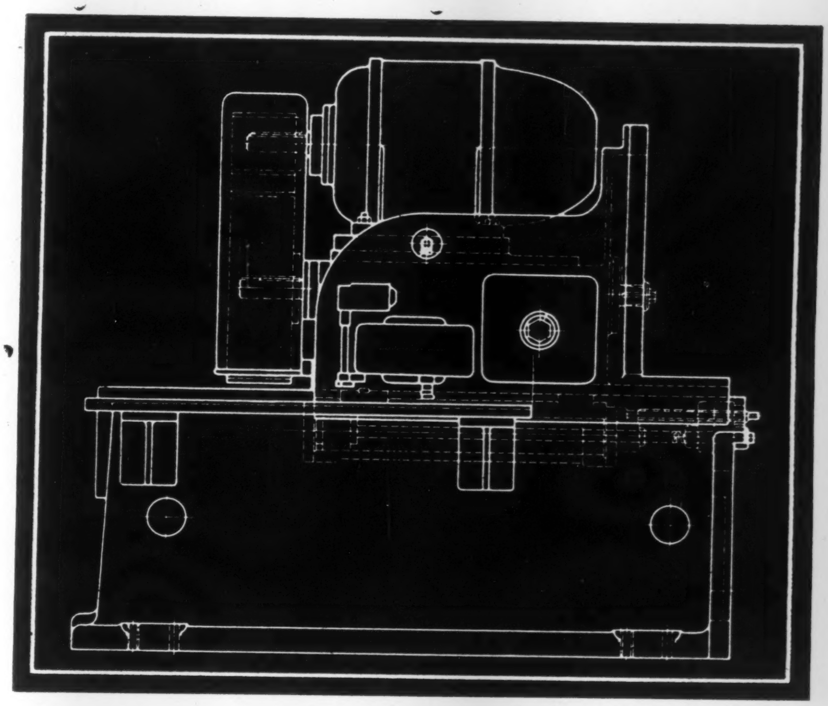
"PACKAGE" UNITS

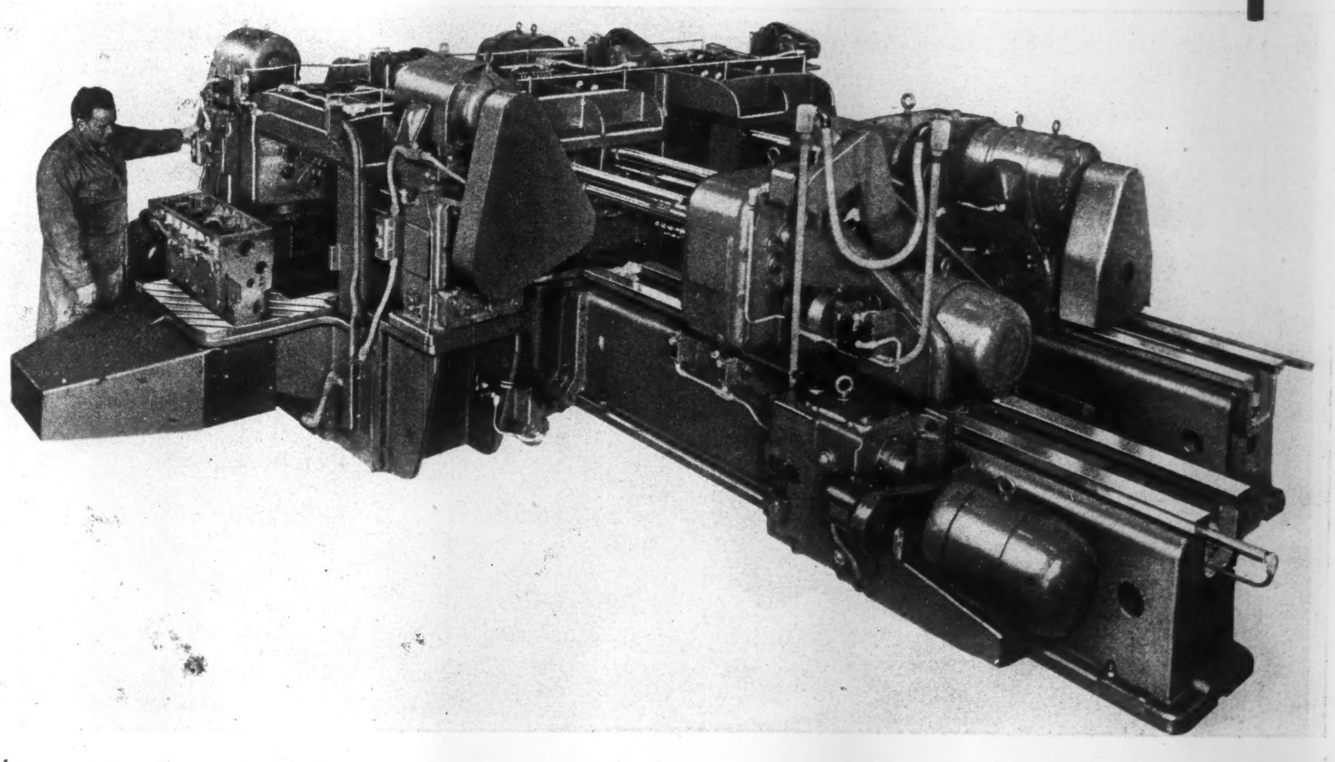
Milling-Drilling

OF A NEW "progress through" unit type construction, the machine below is especially laid out for the processing of eight-cylinder motor blocks. Designed and built by the W. F. & John Barnes Co., the machine utilizes to advantage their standard SH-12 and SH-16 self-contained hydraulic sliding-head milling, drilling and boring units.

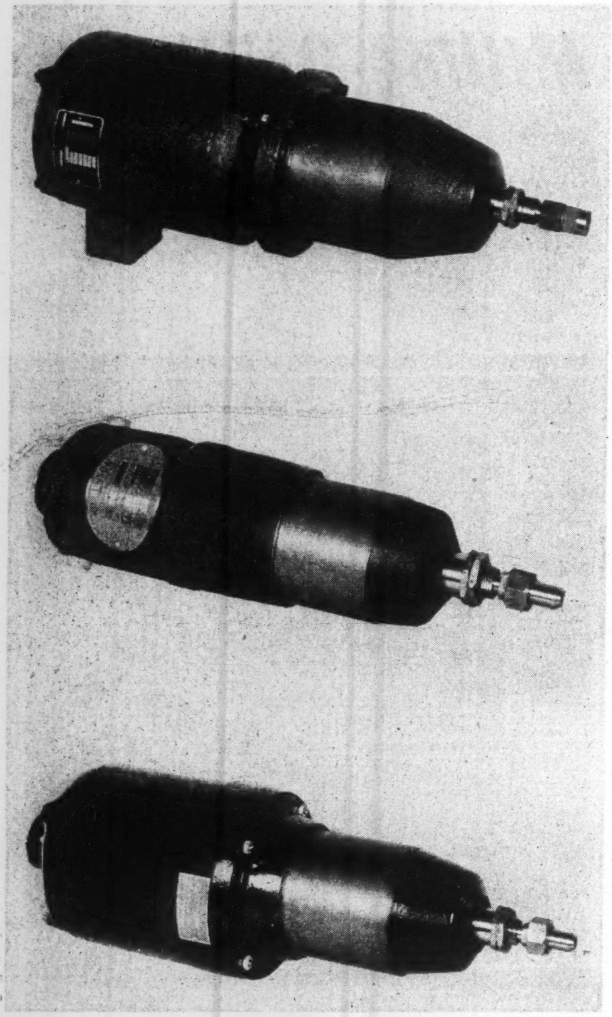
These standard units are primarily an actuating source for feeding and driving power spindles. Single or multiple milling or drilling spindles can be mounted in any desired head and bolted to the face flange of the units. Uniform feed rate to cutting tools is insured by use of positive delivery piston pump and controls furnished by John S. Barnes Corp. Feed rate is adjustable and dwell may be varied from zero in drilling or reaming, to a maximum for counterboring or facing. Standard cycle is rapid approach, feed, dwell (if desired) rapid return, and stop.

On the SH-12 unit, 10 to 15 horsepower is available while on the SH-16, right, 20 horsepower is available, maximum. A John S. Barnes Corp. "package" hydraulic unit is used for actuation of fixture, pusher bar, elevating cylinders, and clamp cylinders. This unit can be seen at the lower right on the machine below.





"PACKAGE" UNITS



Drilling

IDEAL for multiple drilling with small drills—from 1/32-inch to 3/8-inch—the Govro-Nelson centrifugally-driven drilling heads, left, simplify greatly the creation of a production drilling machine. Nine Model "A" heads go to make up the Michigan Die Casting Co. machine, below, which was used to drill eighteen 7/32-inch holes in the fin for the 81-mm shell. Operation is completely automatic, the nine drills simultaneously cutting through a 3/32-inch outer shell of aluminum and then through a 3/32-inch inner shell of SAE 3135 steel. The part, held in a fixture by an air cylinder, automatically indexes after drilling the first nine holes to allow drilling the second nine.

Small and compact, these units are completely self-contained; Model C handling 1/32 to 1/4-inch diameters at 5 to 10,000 rpm with a ¾-inch stroke, Model E handling 1/16 to 1/4-inch diameters at 3500 rpm with 1¼-inch stroke, and Model H handling ⅛ to ⅜-inch diameters at 1750 rpm with a 1¾-inch stroke. A sensitive centrifugal feed mechanism automatically compensates for dull tools and hard spots or changes in material, both protecting tools and permitting high production rates. Equipped with precision switches, units may be wired to drill simultaneously or in sequence and can be arranged to operate indexing devices, etc.

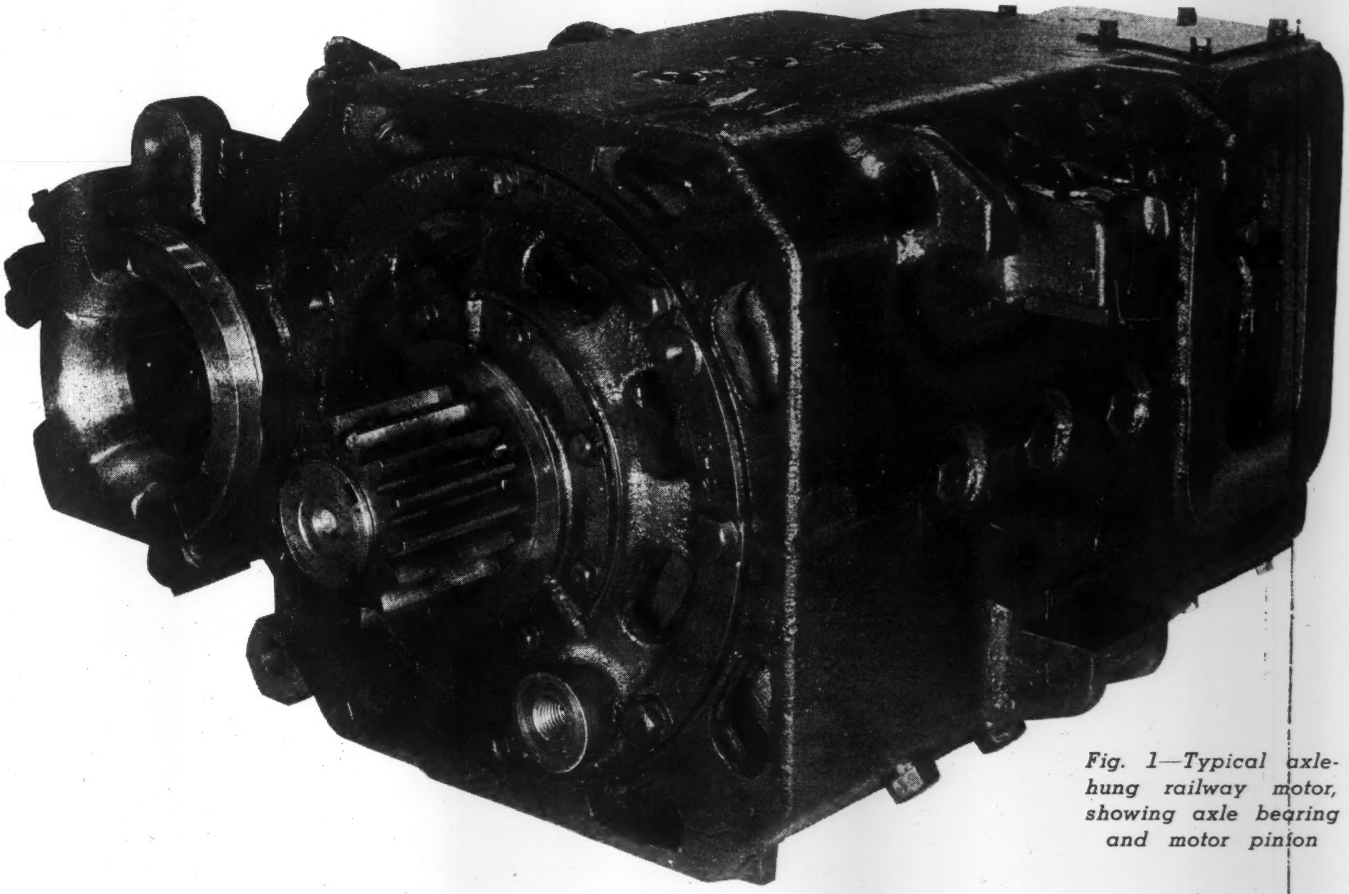


Fig. 1—Typical axle-hung railway motor, showing axle bearing and motor pinion

Design of Gears for Rail Drives

By D. R. Meier and J. C. Rhoads
General Electric Co.
Erie, Pa.

ALTHOUGH some of the early electric motors for rail-transportation vehicles were gearless, with the motor armature mounted directly on the axle, real progress in this field was not achieved until motors were geared to the axles, *Fig.* 1. The early gears were cast and relatively soft, but their quality steadily improved and greater load-carrying capacity resulted as design knowledge was acquired. Gear development has kept pace with motor development, so that as motor constants permitted higher armature speeds, gears were available to utilize these speeds.

Requirements for railway gearing are quite different from those of other types of gearing. The life should be many times that of automotive gearing which, in most cases, can be designed for a finite number of load cycles, below the endurance limit. Railway gearing on the other hand must usually be designed for 10,000,000 or more cycles of

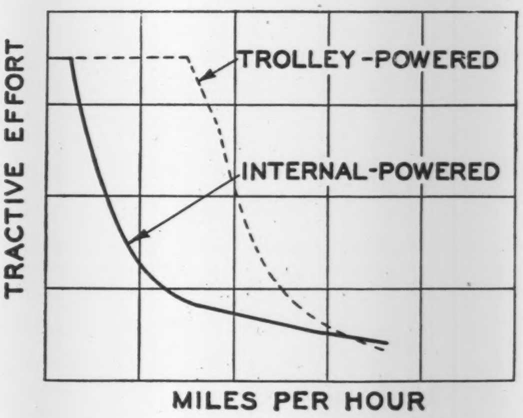


Fig. 2—Characteristic curves for internal-powered and trolley-powered electric locomotives

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Abstract of a paper presented at the recent annual meeting of the American Society of Mechanical Engineers in New York.

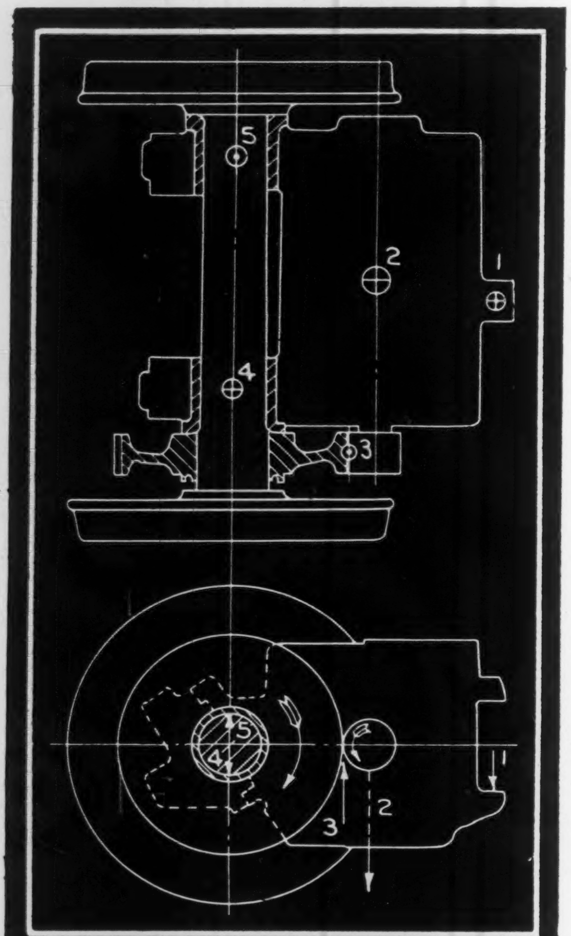


Fig. 3—Sketch of railway motor showing location of (1) motor suspension reaction, (2) motor weight, (3) tangential gear load, (4) and (5) reactions on axle bearings

load application, which is practically equivalent to designing for the endurance limit.

Loading on railway gears varies from extremely high load at low speeds to a relatively light load at high speeds. Comparison of the characteristics of the two general types of duty curves which the motor follows is shown in *Fig.* 2. Because of limited power the internal-powered locomotive develops maximum tractive effort only to a relatively low speed, and as the speed increases the tractive effort decreases, following a constant-horsepower curve. The trolley locomotive, with much less of a power limitation, can for a short period develop maximum tractive effort up to several times the speed of the internal-powered locomotive.

Capacity of the gears must be sufficient to run under adverse conditions of wear and lubrication without complete failure. A gear failure on a locomotive may tie up the whole system for several hours or may cause a complete motor failure due to overspeeding.

Gear noise is relatively unimportant except in street cars or subways, since the noise of the wheels on the rails and other background noise tends to subordinate the gear noise. This situation will change as reductions are made in other noises. But with operators and passengers relatively far removed from the gears, noise will always be of less consequence on vehicles of this type than on applications where the operating personnel must be close to the gears.

Backlash used in railway gears may be considered excessive compared with other types of gears. It has been found from experience that far less trouble is encountered with excessive backlash than with insufficient backlash, since involute-gear action is independent of backlash.

A typical axle-hung railway motor is shown in *Fig.* 1, while *Fig.* 3 is a sketch showing the load reactions of such a motor on an axle. Center distance is held by the armature and axle-suspension bearings, the motor-armature pinion being carried overhung on the armature shaft. Gear-load reactions are taken by the axle-suspension bearings and by the motor nose suspended from the truck, with the locating thrust of the motor taken by flanges on the axle-suspension bearings. At maximum gear loads for the direction of rotation of the motor shown in *Fig.* 3, the reaction on the axle bearing adjacent to the gear is down, whereas the reaction on the opposite bearing is up. This results in a misalignment of the gear mesh equal to the bearing clearance divided by the length between bearings.

Gear cases are usually made in two halves with the split on a horizontal plane through the gear centers, to provide easy removal for maintenance and inspection. Considerable clearance is provided in the gear-case fit around the axle to take care of axle-lining wear and gaskets are not used at the joints. For these reasons lubricants of high viscosity must be used to keep leakage to a minimum.

Maintaining Conjugate Tooth Action

In general it is necessary to have motors and axles interchangeable, although experience is dictating the need for keeping gears and pinions together. Where a motor is removed the pinion is wired to the axle until a new motor is installed, the pinion then being mounted on the new motor shaft. Gears that are worn together maintain conjugate tooth action, but a pinion worn with one gear and mated with another will generally have excessively rough tooth action, which may cause loose armature punchings, insulation failures, broken shafts, failed bearings, and actual gear failures.

Five general types of failures are encountered on railway-type gearing. Tooth breakage is usually caused by fatigue and occurs infrequently in railway applications. Such a failure necessitates replacement of the broken element, and generally also of the mating member since it is common for a tooth to get caught in the mesh when it breaks out. It is also possible for the armature shaft to be bent when such a failure occurs.

Pitting of gearing is a rather common failure caused by too high a compressive stress for the material used. A certain amount of pitting does not necessarily mean that gearing must be removed from service, as it is not uncommon for very heavily loaded gears to pit when new, and for the pitting to stop as the gears wear to more nearly full-face contact.

Spalling is a type of failure (sometimes termed shelling or flaking) wherein large pieces of the tooth surface may come out almost anywhere on the profile from the root to the tip of the tooth. This type of failure is generally attributed to improper material, heat-treatment, or processing. Such a failure is far more serious than pitting, because a considerably higher percentage of the surface is removed.

Scuffing is caused by metal-to-metal contact between a mating gear and pinion, due either to improper lubricant or to improper lubrication. In most railway-gear applications, scuffing is due to lack of lubrication and not to excessive loads or speeds. In some instances, gears that are very heavily loaded at high speeds will scuff even with the proper amount of lubricant, and in such cases extreme-pressure lubricants are indicated.

Excessive wear may be caused by insufficient or improper lubrication. Another cause is abrasive material in the lubricant, which acts as a lapping compound and can cause a great amount of wear. Such wear is characterized by a lapped appearance varying from a highly polished to a deeply scratched surface, depending on the size of foreign particles in the lubricant. The scratches are radial from root to tip on the profile. Experience has shown that where it is possible to provide oil-tight gear cases which will retain lubricants of reasonable viscosity, and which will keep foreign material out of the lubricant, gear wear is negligible.

Spur gears are used in the majority of railway applications because they (a) create no end thrust; (b) are simple in design and easy to manufacture; (c) are interchangeable; (d) are not critical with respect to center distances; (e) have good efficiency. Other types of gearing such as helical, spiral-bevel, and hypoid are used on special applications where noise, geometry, or other considerations dictate their use.

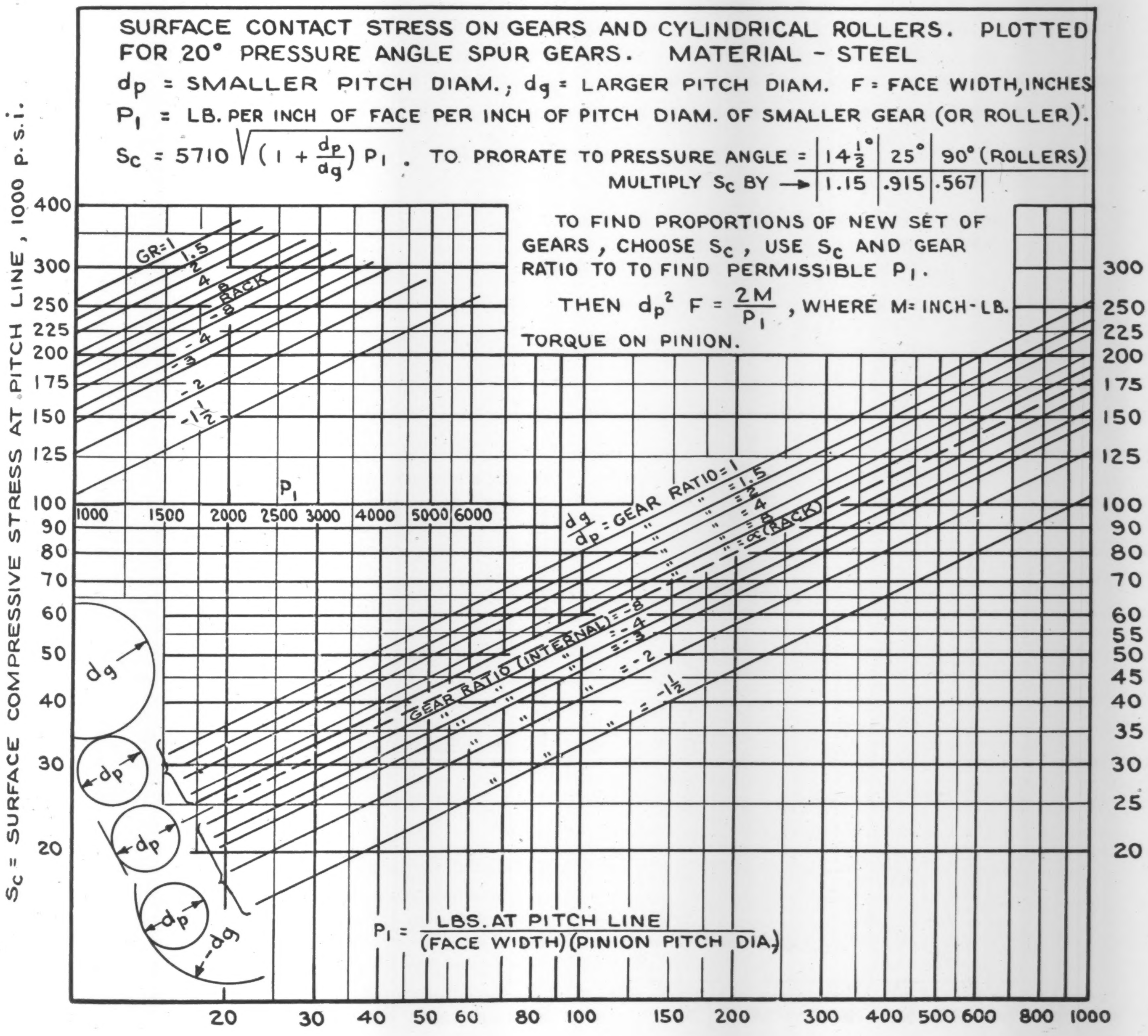
Axle-hung railway motors usually have antifriction armature bearings, but sleeve-type axle-suspension bearings. The axle bearings may operate with relatively large diametral clearance, therefore it is important that the gears used be able to accommodate themselves to the spread in centers which occurs with wear.

Taking into account the foregoing factors, the major considerations in the design of railway gears are as follows:

1. Tooth strength in bending
2. Tooth surface durability
3. Tooth proportions
4. Number of teeth in action.

By far the most important of these is tooth strength. A failure due to tooth breakage may seriously damage the motor or break the mating-gear member. Even if no dam-

Fig. 4—Chart for determining compressive stresses on the surfaces of gear teeth in contact



age results, expensive equipment must be taken out of service to make repairs. Adequate strength for wear must be provided, but excessive wear is not as serious as tooth breakage because replacements can usually be made before complete failure occurs.

Since the traction-motor size and weight are so closely dependent on gear ratio, there is always the incentive to get as much gear reduction as possible on new designs. This applies especially to high tractive-effort slow-speed switching locomotives. The gear diameter is determined by the wheel diameter and the clearance to be provided between the gear case and the rail; therefore the pinion must be reduced in size if higher reductions are to be obtained.

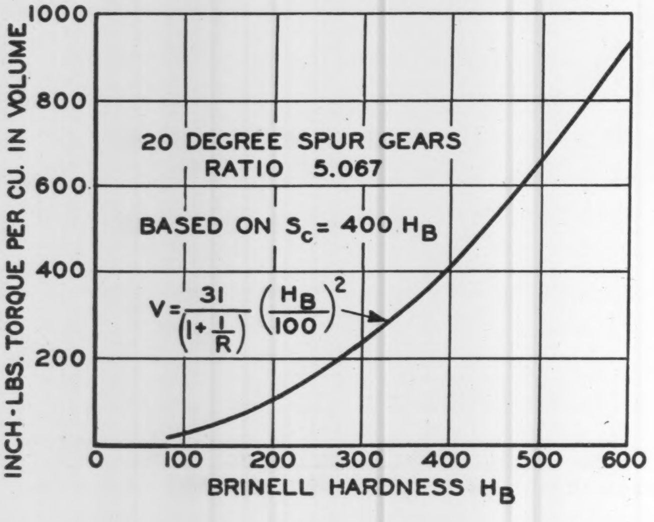
Static Strength Is Basis for Design

It has been shown, *Fig.* 2, that the maximum load on the gearing occurs at the lowest speed on the characteristic curve. The pitch-line velocity at this point may be from 200 fpm on internal-powered switching locomotives to 2000 fpm on trolley locomotives. In the case of internal-powered locomotives, on maximum reduction the pitch-line speed is so low as to make dynamic loading negligible; therefore static-stress calculations are used directly. In the case of locomotives where greater pitch-line speeds are used, the calculations are also made on a static-stress basis, but the values of allowable stress are decreased, based on service and test data to allow for increased dynamic loading.

For all stress calculations it is assumed that the load is uniformly distributed along the face of the tooth. It is realized that this condition cannot be obtained in practice, because of slight misalignment due to machining errors, bearing wear, and deflection of loaded parts, including the shaft, bearings, pinion, and gear teeth. Therefore, in using the equations of elasticity to calculate stresses, it will be recognized that the assumption of uniform distribution of load is not valid. However, this need not detract seriously from the value of the calculations as long as conventional design proportions, for which service data are available, are used.

It has been found satisfactory to use the Lewis formula for the calculation of bending stress. This is more conservative than methods which involve the number of teeth in action, or methods which are based on applying the load at the highest point on the tooth at which one tooth carries all of the load. However, in a field of service where interchanging of gears and pinions is freely practiced, with the probable result that worn (nonconjugate) profiles will be run together and where operation under adverse conditions occurs frequently, conservatism must be practiced.

Fig. 5—Curve showing relationship between pinion torque capacity and the hardness of the material



It is usually desirable to provide 10 to 15 per cent greater strength in the pinion tooth than in the gear tooth, because of the greater number of revolutions of the pinion with attendant greater wear.

The problem of obtaining sufficient strength in the pinion tooth tends to limit the design, because strengthening the tooth requires coarsening the pitch, which works to the detriment of good tooth action. Stubbing the teeth has the same effect, though in some cases it may be preferable to using a coarser pitch.

In using the Lewis equation for bending it has been found convenient to express the tooth-form factor, y, in the form

$$y = \frac{N}{A'N + B'} \quad \ldots\ldots (1)$$

where A' and B' are arbitrary constants and N is the number of teeth in the pinion. As may be readily shown, this equation can be combined with the Lewis equation

$$S_b = \frac{W}{pFy} \quad \ldots\ldots (2)$$

to give the equation

$$S_b = P_1(AN + B) \quad \ldots\ldots (3)$$

for bending stress, S_b, where P_1 is the pounds per inch of face per inch of pinion pitch diameter, W being the tangential tooth load, p the circular pitch and F the face width.

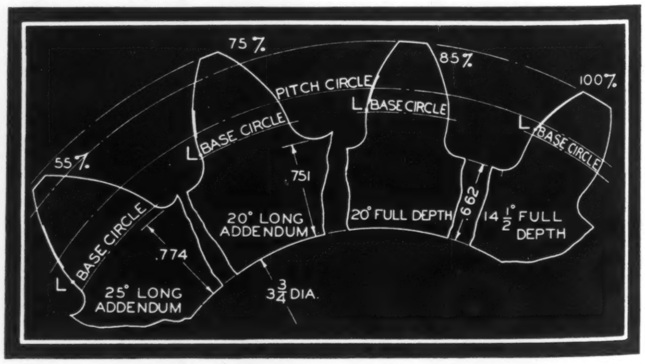
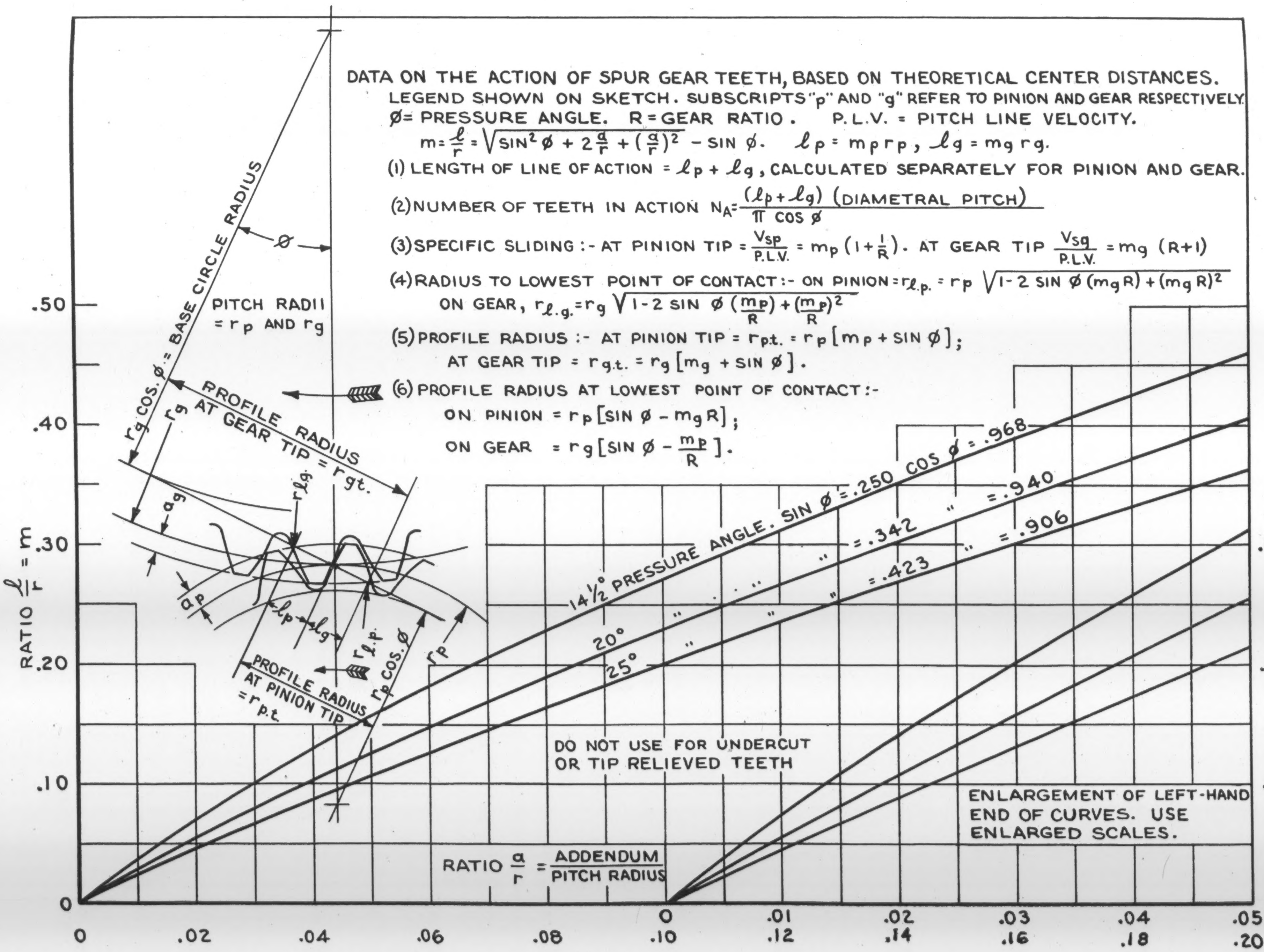


Fig. 6—Comparison of tooth proportions

For three systems of gearing examined by this method, it developed that the constants A and B could be made integral numbers and still have the expression accurate within a few per cent for numbers of teeth between 15 and 35. This satisfactorily covers the range of pinion-tooth numbers normally used. It is not necessary that this expression



DATA ON THE ACTION OF SPUR GEAR TEETH, BASED ON THEORETICAL CENTER DISTANCES.

LEGEND SHOWN ON SKETCH. SUBSCRIPTS "p" AND "g" REFER TO PINION AND GEAR RESPECTIVELY.

ϕ = PRESSURE ANGLE. R = GEAR RATIO. P.L.V. = PITCH LINE VELOCITY.

$m = \frac{\ell}{r} = \sqrt{\sin^2 \phi + 2\frac{a}{r} + \left(\frac{a}{r}\right)^2} - \sin \phi$. $\ell_p = m_p r_p$, $\ell_g = m_g r_g$.

(1) LENGTH OF LINE OF ACTION = $\ell_p + \ell_g$, CALCULATED SEPARATELY FOR PINION AND GEAR.

(2) NUMBER OF TEETH IN ACTION $N_A = \frac{(\ell_p + \ell_g)\,(\text{DIAMETRAL PITCH})}{\pi \cos \phi}$

(3) SPECIFIC SLIDING :- AT PINION TIP $= \frac{V_{sp}}{\text{P.L.V.}} = m_p\left(1 + \frac{1}{R}\right)$. AT GEAR TIP $\frac{V_{sg}}{\text{P.L.V.}} = m_g\,(R+1)$

(4) RADIUS TO LOWEST POINT OF CONTACT :- ON PINION $= r_{\ell.p.} = r_p \sqrt{1 - 2 \sin \phi\,(m_g R) + (m_g R)^2}$

ON GEAR, $r_{\ell.g.} = r_g \sqrt{1 - 2 \sin \phi \left(\frac{m_p}{R}\right) + \left(\frac{m_p}{R}\right)^2}$

(5) PROFILE RADIUS :- AT PINION TIP $= r_{p.t.} = r_p\,[m_p + \sin \phi]$;

AT GEAR TIP $= r_{g.t.} = r_g\,[m_g + \sin \phi]$.

(6) PROFILE RADIUS AT LOWEST POINT OF CONTACT :-

ON PINION $= r_p\,[\sin \phi - m_g R]$;

ON GEAR $= r_g\left[\sin \phi - \frac{m_p}{R}\right]$.

DO NOT USE FOR UNDERCUT OR TIP RELIEVED TEETH

ENLARGEMENT OF LEFT-HAND END OF CURVES. USE ENLARGED SCALES.

BASE CIRCLE RADIUS
$r_g \cos \phi$ =
ϕ
PITCH RADII = r_p AND r_g
PROFILE RADIUS AT GEAR TIP = $r_{gt.}$
r_g
a_g
$r_{\ell g.}$
a_p
ℓ_p
ℓ_g
$r_{\ell.p.}$
$r_p \cos \phi$
r_p
PROFILE RADIUS AT PINION TIP = $r_{p.t}$
$14\frac{1}{2}°$ PRESSURE ANGLE. SIN ϕ = .250 COS ϕ = .968
20° " " = .342 " = .940
25° " " = .423 " = .906
RATIO $\frac{\ell}{r} = m$
RATIO $\frac{a}{r} = \frac{\text{ADDENDUM}}{\text{PITCH RADIUS}}$
.50
.40
.30
.20
.10
0
0
.02
.04
.06
.08
0
.10
.01
.12
.02
.14
.03
.16
.04
.18
.05
.20
.15
.10
.05
0

Fig. 7—Chart for calculating the action of spur-gear teeth

apply to the gear, since the gear-tooth strength is not limiting. This method applied to the 20-degree-full-depth system leads to the equation $S_b = P_1(2N+22)$, which has an error of less than 2 per cent between 15 and 35 teeth.

Equation 3 is convenient for calculating bending stresses because it eliminates the necessity for consulting a table of y factors. Also it utilizes the independent variable P_1 as it is used later in the compressive-stress equation. If the value of P_1 is substituted in Equation 3, together with the value of permissible bending stress, the minimum number of teeth for satisfactory strength may be calculated. If this number turns out to be prohibitively low, an increase in pinion volume will be required, as will be evident from reference to Equation 6.

It will be noted that the foregoing relations do not take stress concentration due to tooth-fillet radii into account. Since practically all of the gearing used on railway motors has continuous-radius fillets, in which the ratio of fillet size to tooth size is approximately a constant, it is assumed that the stress-concentration factor is the same for all teeth.

It is recognized that any method of calculation of tooth-bending stress is approximate unless sufficient test data are available to permit the development of empirical relations for correlating bending stress with fatigue life. Such data are obtained from testing machines and actual service.

Calculating Surface Compressive Stresses

Load is transmitted from pinion to gear through a relatively narrow contact band formed by the elastic deformation of the contacting surfaces. The compressive stress at the contacting surfaces—which depends on the unit load, the radii of curvature of the surfaces, and the modulus of elasticity—has been shown to be the criterion for pitting of gear teeth and rollers. The compressive stress also influences the rate of wear of gear teeth when they are loaded below the pitting limit. The equation for calculating the compressive stress between cylindrical surfaces in contact is easily modified to give the following equation for surface-contact stress at the pitch line of steel gears and pinions

$$S_c = 3240\sqrt{\frac{P_1(1+1/R)}{\sin\phi\cos\phi}} \quad \ldots\ldots(4)$$

where ϕ is the pressure angle. For 20-degree pressure-angle gearing, this reduces to

$$S_c = 5710\sqrt{P_1(1+1/R)} \quad \ldots\ldots(5)$$

For internal gears the $1/R$ term has a minus sign.

Equation 4 shows that the effect of increasing the pressure angle is to lower the compressive stress. It also shows that the compressive stress is independent of the number of teeth for a given diameter and ratio. The criterion for severity of loading is the variable P_1, the pounds per inch of face per inch of pinion pitch diameter. It has already been shown that this variable can conveniently be used to calculate bending stress.

To facilitate the calculation of compressive stress, the curves shown in *Fig.* 4 are used. These curves show the compressive stress as a function of the unit loading P_1, for the various gear ratios and pressure angles. They serve equally well for calculating the stress on existing gear sets or for designing new gear sets.

By combining the tangential-load equation $W = 2M/d_p$ with $P_1 = W/d_pF$, the relationship

$$d_p^2F = \frac{2M}{P_1} \quad \ldots\ldots(6)$$

is obtained, where M is the pinion torque and d_p is the pinion pitch diameter. This equation shows that the pinion volume is proportional to the torque and inversely proportional to P_1. The value of P_1 may be established by choosing the value of compressive stress and referring to the curves of *Fig.* 4. The same result may be obtained by combining Equations 4 and 6 to give

$$d_p^2F = \frac{2M(1+1/R)}{\left(\frac{S_c}{3240}\right)^2 \sin\phi\cos\phi} \quad \ldots\ldots(7)$$

This relationship shows that the volume of the pinion pitch cylinder is inversely proportional to the square of the compressive stress. Where weight and space are important the use of high compressive stresses is therefore necessary.

Magnitude of the compressive stress which will give satisfactory life may be judged by the designer from experience. Data from various tests show that the endurance limit of steel in surface compression is approximately

$$S_f = 400(H_B) \quad \ldots\ldots(8)$$

where H_B is the brinell hardness number. Since the tensile strength is about 500 times the brinell hardness number, the endurance limit for surface compression is roughly 80 per cent of the tensile strength.

The applicability of roll-test data to gear design may be questioned but it has been the authors' experience that gears will operate successfully at stresses approaching the value of 400 times the brinell hardness. This experience covers a wide variety of designs, including different types of materials, heat treatments, and manufacturing methods, together with various designs of gear elements and mountings. Just how close to this value the gears may be stressed depends on (a) how much dynamic load will be superimposed on the static load (a function of the pitch-line speed, the mass and stiffness of the connected parts, and the errors in various parts, particularly the gears); (b) how well the load will be distributed over the tooth length; (c) the life expected in the gearing; and (d) other factors such as surface finish, etc.

To show the relationship between pinion-torque capacity per unit volume and material hardness, *Fig.* 5 has been plotted from Equations 7 and 8. The ratio of bending stress to tensile strength tends to be higher for hard materials than for soft materials, assuming that in each case the material is loaded to its compressive-stress endurance limit. As advantage is taken of harder materials for carrying higher loads, bending failures are more likely to occur than pitting failures.

Many different systems of spur gearing are in use, in-

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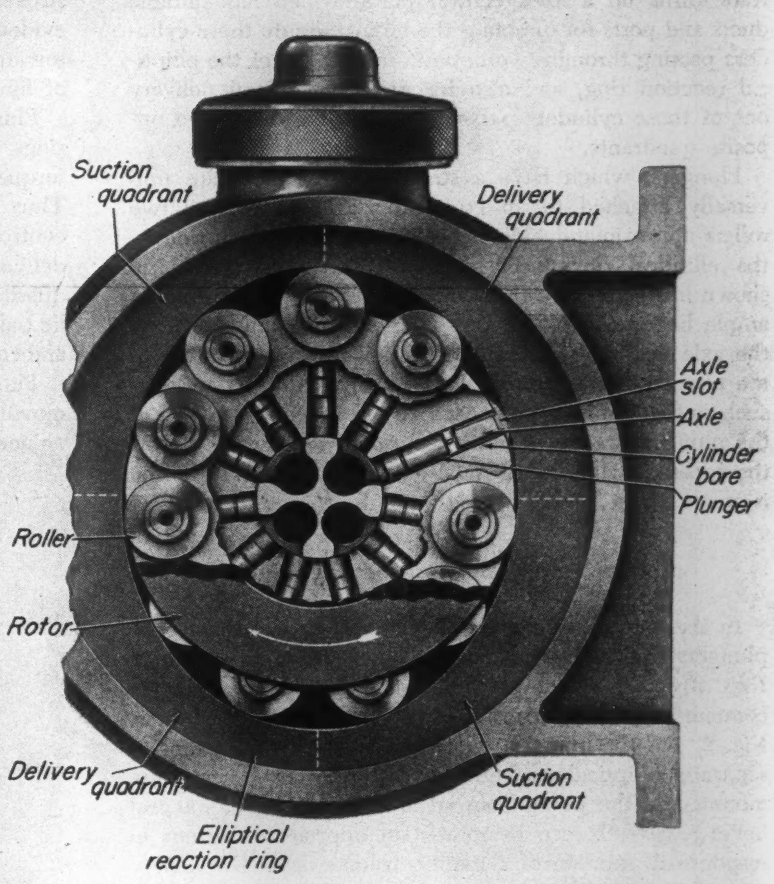
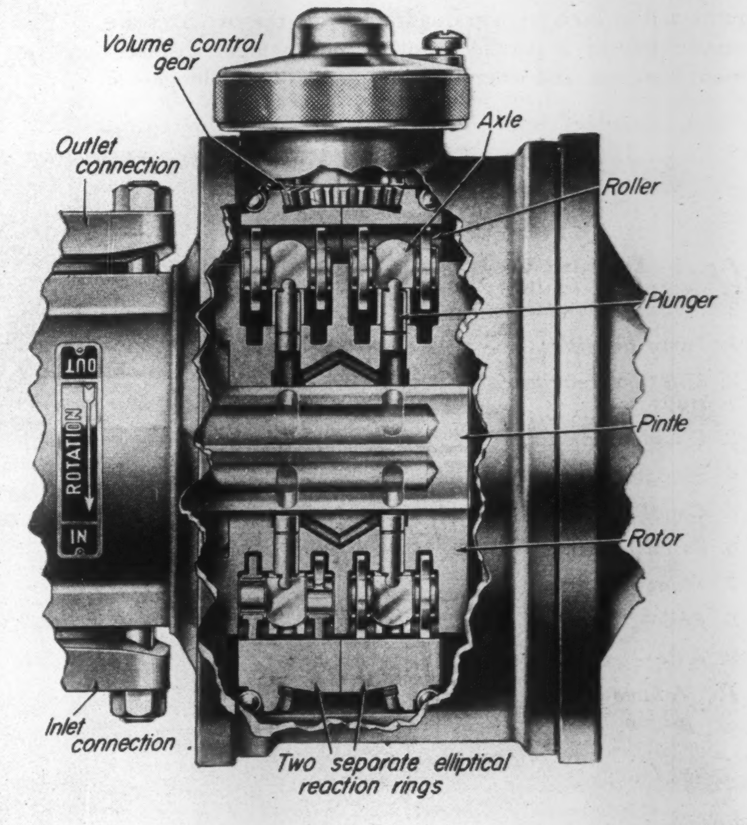
Twin Ellipses Provide Unique Pump Action


Suction quadrant
Delivery quadrant
Axle slot
Axle
Cylinder bore
Plunger
Roller
Rotor
Delivery quadrant
Elliptical reaction ring
Suction quadrant


Volume control gear
Outlet connection
Axle
Roller
Plunger
OUT
ROTATION
IN
Pintle
Rotor
Inlet connection
Two separate elliptical reaction rings

By A. H. Allen

Detroit Editor, Machine Design

EMBODYING unusual principles of design and construction, the radial-type pump shown in *Fig.* 1 is capable of constant or variable delivery of hydraulic power up to 5000 psi and 40 horsepower. Recently developed by engineers of the Superdraulic Corp., a subsidiary of Hydraulic Machinery Inc., the new pump is adaptable for use in mobile equipment, including automotive, railroad and marine power drives as well as for general hydraulic power applications.

Employment of elliptical reaction rings gives each plunger two double strokes per revolution, thus making possible a high displacement in relation to the overall size of the unit. Plungers are fitted to cylinders in a rotor with one or

Fig. 1—Top—Cross-section of pump showing elliptical reaction ring and 11 radial plungers

Fig. 2—Right—Axial section of pump showing elliptical reaction rings, double rollers and universal construction of plunger assembly

more banks of 11 plungers per bank, *Figs.* 1 and 2. The rotor turns on a fixed central pintle which has suitable ducts and ports for directing the oil intake into those cylinders passing through two opposite quadrants of the elliptical reaction ring, and also for directing the oil delivery out of those cylinders passing through the other two opposite quadrants.

Plungers, which have a stroke of 9/16-inch, are universally attached to an equalizing axle supporting two rollers approximately 1⅜ inches in diameter, which ride on the elliptical rings. This construction, which is clearly shown in *Fig.* 2, and in the detail view on *Fig.* 3, provides ample bearing areas for the plunger load components on the axle bearing surfaces and insures zero side loading of the plunger. This permits various forms of reaction rings such as the ellipse to be used. To insure against failure of the plungers to return when the pump is operated below the speed at which centrifugal force is adequate, provision is made for a simple spring-type return means.

Control Rotates Elliptical Reaction Rings

In the variable-delivery type of pump, two banks of 11 plungers each are arranged in a single rotor, as shown in *Figs.* 2 and 3. Each pair of parallel cylinders is in open communication by means of a drilled passage in the rotor, *Fig.* 2, and the plunger rollers of each bank roll against a separate elliptical reaction ring. The two rings are mounted in the pump housing and, by means of integral bevel-gear teeth, can be rotated in opposite directions in response to rotation of a mating volume-control pinion.

At full delivery the major axes of the elliptical reaction rings are parallel, while at zero delivery they are 90 degrees apart. At zero delivery the displacement of the plungers moving radially outward exactly equals that of the plungers moving radially inward in both delivery quadrants and in both suction quadrants. As the two axes are moved toward a parallel position, net plunger displacement increases, and when they are parallel both plungers of a pair reciprocate in phase through full delivery and suction strokes. With the rings in zero delivery position, it is evident that they may be moved in either of two directions toward a parallel position. This makes possible a reversal of flow of the pressure fluid.

Plunger reaction loads exerted on the elliptical reaction rings are balanced through the volume control gear, the torque of one reaction ring balancing that of the other. Thus sensitive manual or automatic pressure and volume controls can be used. Inasmuch as suction quadrants and delivery quadrants are diametrically opposite in the four quadrants of the elliptical reaction ring, there is hydraulic balance between pintle and rotor and between plungers and rotor.

Pump housing, *Fig.* 4, is of alloy cast iron, while the moving parts generally are of alloy steel, precision machined. In the case of the plungers, tolerances are about

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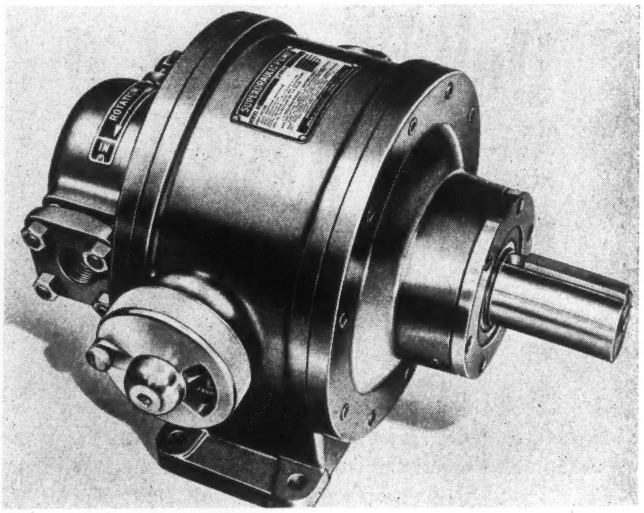


Fig. 4—Complete variable-delivery pump unit as developed for industrial hydraulic applications

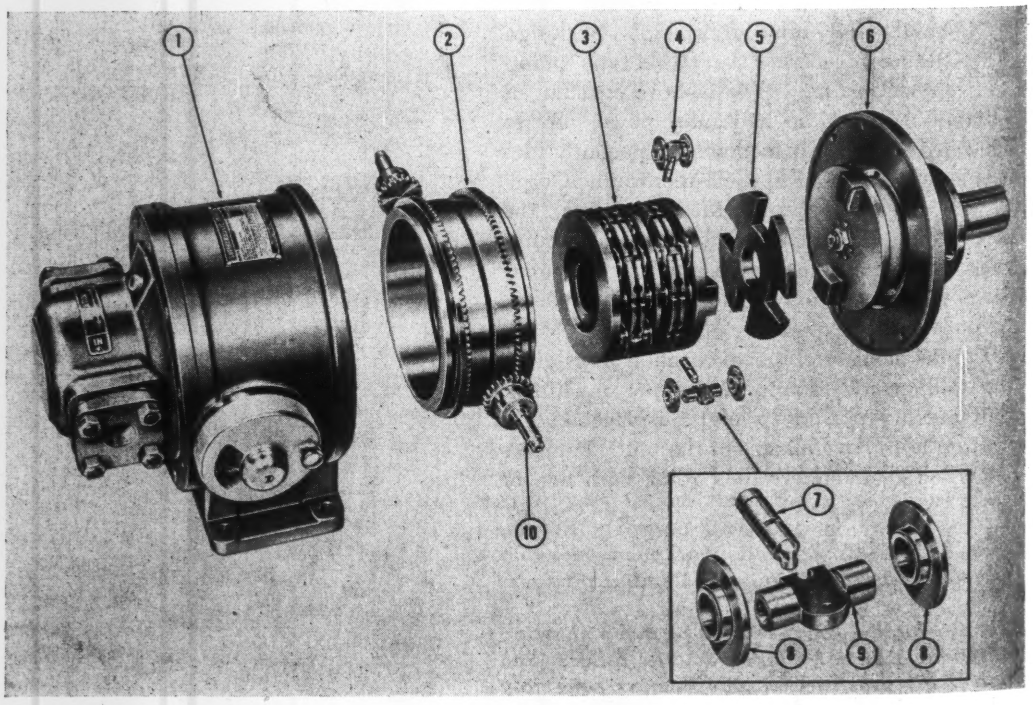


Fig. 3—Exploded view of variable - delivery pump showing:

1. *Pump housing*
2. *Elliptical reaction rings*
3. *Double-bank rotor*
4. *Plunger assembly*
5. *Coupling Disk*
6. *Drive housing*
7. *Plunger*
8. *Rollers*
9. *Axle*
10. *Volume-control pinion*

How To Apply COUNTERS in Machines

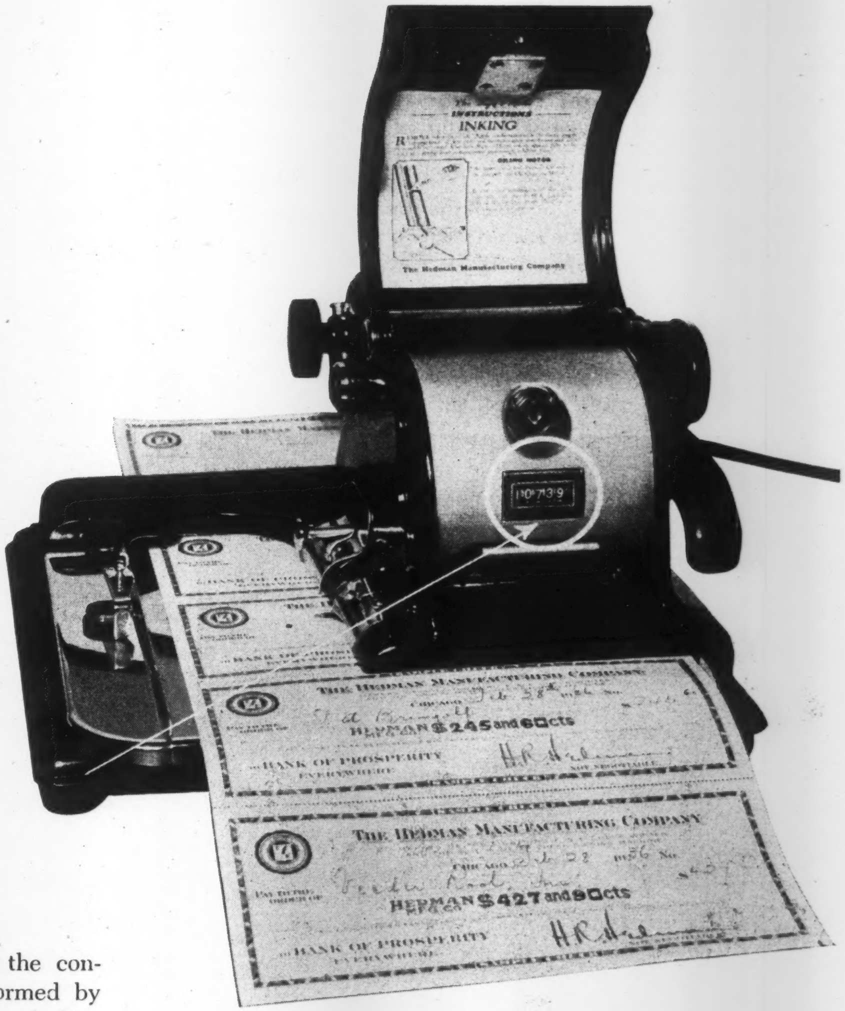


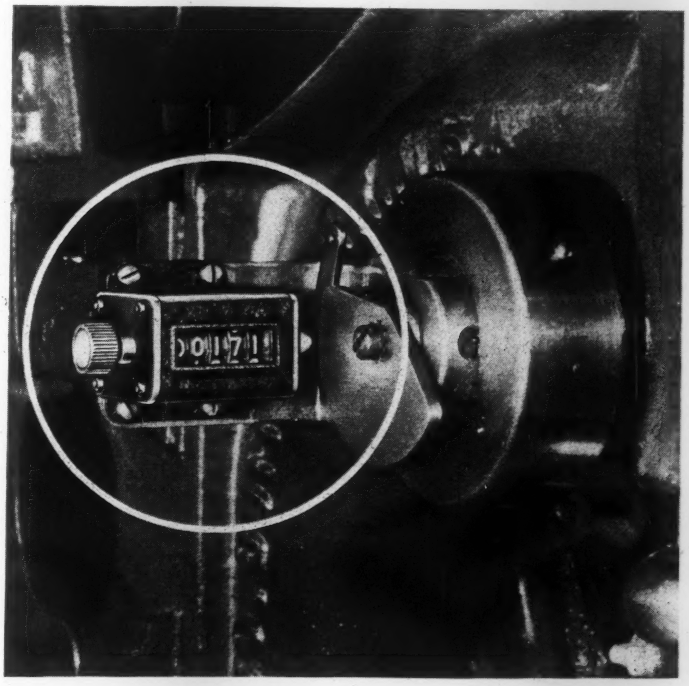
Fig. 1—Above—Small reset counter built into check-signing machine illustrates neat appearance resulting from application of the counter as an integral part of the machine

ADAPTABLE to the counting or even the controlling of many of the functions performed by machines, modern counting devices are finding ever-increasing applications. Their usefulness, however, continues only as long as the counter does its job accurately and consistently. Too often the counter is hung on as an afterthought, and if this is done by the user there is no assurance that sound engineering principles will be applied in selecting the counter or in designing the drive for it. By incorporating the counter into the original design of the machine, as in *Fig.* 1, the designer can insure neat appearance, and by correct selection and application he can furnish the user with a device that will count accurately and reliably throughout the life of the machine.

In this article the salient features of the more commonly used types of counters are briefly reviewed, and the important factors in specifying and applying them are discussed. It is hoped that the information will be helpful to designers and possibly stimulate their thinking on new applications or improved methods of applying counters as integral parts of their machines.

First step in selecting a counter is to determine how complete a job is to be done. At one end of the scale is the simple nonreset counter which at any moment gives a visual indication of total count up to that time. At the other end there is the Chronolog which not only counts but prints a record of the count along with a record of clock time and down time of the machine and the reason for stoppage. In between is a variety of devices which are capable of meeting almost any reasonable requirement. The principal types of mechanical

Fig. 2—Below—Reset ratchet counter on bench drill press. Oscillation of counter lever is provided by rotary cam



counters may be classified as follows:

a. *Direct-drive counters*, in which the "units" wheel, i.e., the one at the extreme right, turns continuously at the speed of the driveshaft. Figures on this wheel therefore represent tenths of a revolution of the driveshaft. Reverse revolutions are subtracted from the reading.

b. *Revolution counters*, in which the "units" wheel registers one figure for each revolution of the driveshaft. A direct-drive counter becomes a revolution counter if the units wheel is blanked off, in which case reverse revolutions are subtracted from the reading.

c. *Rotary rachet counters*, employing a ten-tooth ratchet to drive the units wheel, which add one unit for each one-tenth revolution of the driveshaft in one direction. Reverse rotation of the driveshaft, or oscillation through less than one-tenth of a revolution, does not register.

d. *Ratchet counters*, with stops, in which the driveshaft movement is limited to an oscillation sufficient to actuate the ratchet. A return spring may be incorporated in the counter.

e. *Geared counters*, which employ built-in gears to give any desired relation between driveshaft turns and reading. The "ratio" of a geared counter is defined as the number of driveshaft turns to indicate one unit on the units wheel.

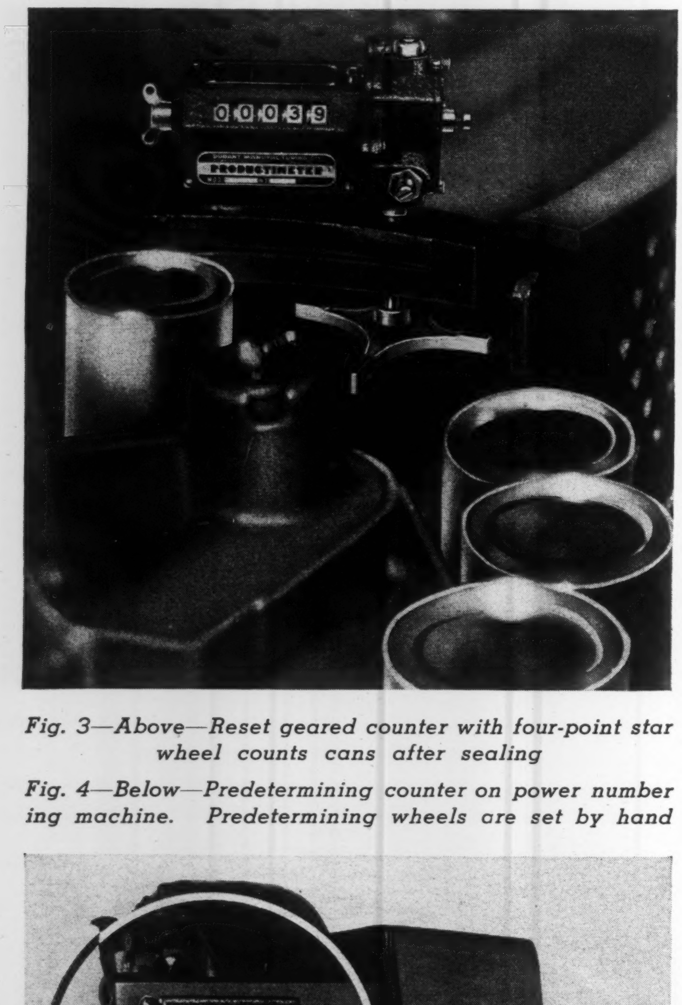
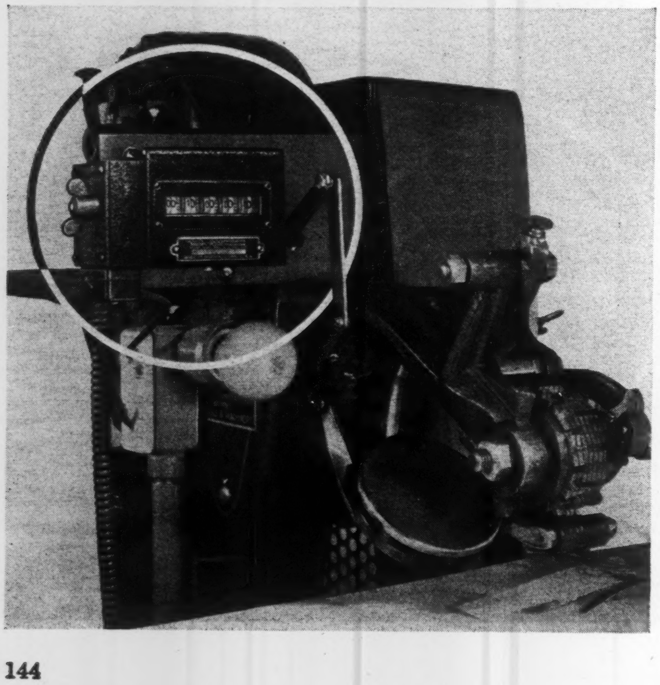


Fig. 3—Above—Reset geared counter with four-point star wheel counts cans after sealing

Fig. 4—Below—Predetermining counter on power numbering machine. Predetermining wheels are set by hand



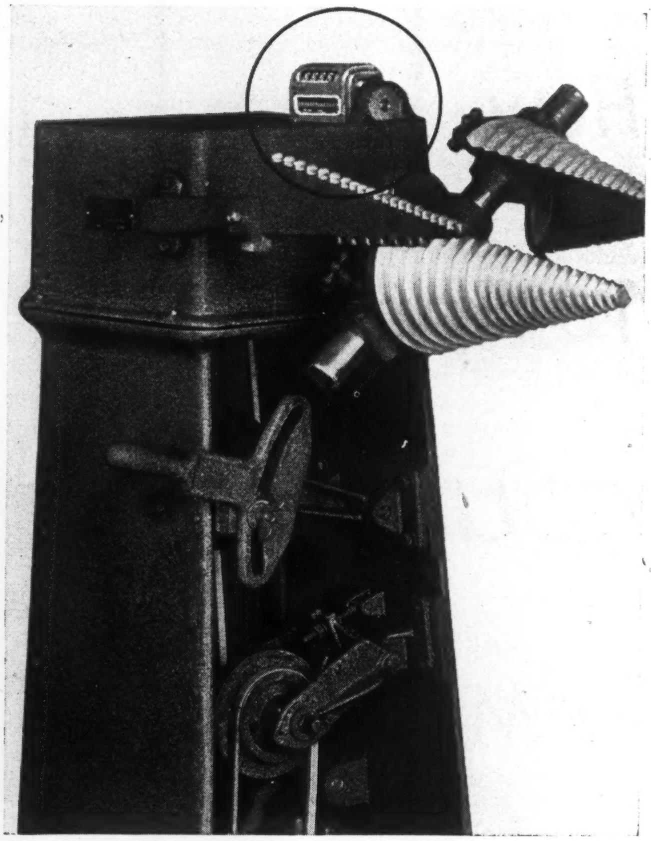


Fig. 5—Geared counter on coil-winding machine is chain driven, internal gear ratio being chosen to suit application

Any of the foregoing types of counters may be provided with a reset mechanism for turning the figure wheels back. A convenient knob, as shown in *Fig.* 2, or a wingnut, as in *Figs.* 3 and 4, may be employed, but if it is desired to prevent tampering by unauthorized persons the use of a tumbler lock and key, *Fig.* 1, is recommended. Inasmuch as ordinary reset mechanisms may require several turns to bring all the wheels back to zero, a quick reset feature can be incorporated whereby one turn is sufficient to zero the counter.

Predetermining Counters as Controls

Another highly useful modification of the basic style of counter is the predetermining counter, an example of which is shown in *Fig.* 4. As the illustration shows, the counter has two sets of figure wheels—the predetermining wheels and the counting wheels. The former are set by hand to the desired number for the run, while the latter are

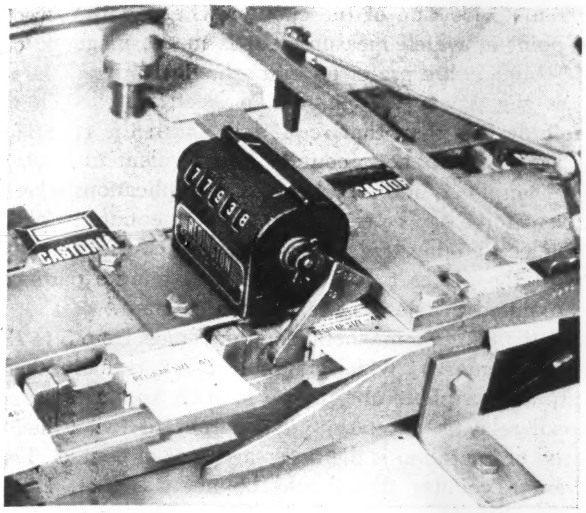


Fig. 6—Ratchet counter applied to carton-filling machine employs special piece added to standard lever extending its length

set to zero by the reset nut. In operation, the predetermining wheels subtract and the counting wheels advance, and when the latter reach the predetermined number a contactor built into the housing makes or breaks an electric circuit. This action may be employed to light a lamp, ring a bell, stop the machine, start a motor, etc. When the machine is to be stopped, braking action should be incorporated to prevent the machine's overtraveling. To avoid burning the contactor points, a relay should be used if the circuit to be controlled exceeds the equivalent of 1 ampere at 110 volts.

Predetermining counters may be applied to continuous production operations as, for example, in the case of a machine which produces bottle caps and delivers them to cartons. As the caps slide down a chute into the carton they are counted and when the predetermined number is reached the chute is automatically closed while the carton conveyor is started, taking away the filled carton and replacing it with an empty one. At the same time the counter resets itself and starts counting caps for the next carton.

Avoiding Troubles Due to Excessive Speed

In selecting a counter, it is important to see that the intended operating speed is not more than the maximum counting rate for which it was designed, inasmuch as the intermittent drive to the counter wheels at the tranfer points may involve high accelerations. The resulting torque due to the inertia of the wheels has two detrimental effects on counter operation: In the first place, the loading on the transfer mechanism is high, particularly when several figure wheels are turned simultaneously, and in the second place there is a tendency for the wheels to "overtravel", or coast beyond their proper position, unless special checks are employed to prevent this. Reduction of the inertia by using smaller diameter figure wheels has its drawbacks, inasmuch as the figures may become too small for convenient reading; even with magnifying lenses, the figures are distorted and cannot be read from as wide an angle.

Special high-speed counters are available, with lightweight wheels, but in many cases an equally good solution is to use a reduction gear. Dummy zeros can be engraved on the housing so that the total number of digits corresponds to the number being counted. Thus, a revolution counter geared 10 to 1 would require one cipher to the right of the "units" wheel. Alternatively, a direct-drive counter with a 10-to-1 external gear would read actual revolutions on the counter wheels.

Select Counter To Suit Environment

Ambient conditions may affect the selection of a counter or at least should be included in the specification if unusual. Moisture-proof or dust-proof housings may be necessary, while if extremely high or low temperatures are to be encountered the counter manufacturer should be told so that he may use the proper lubricant in assembling the unit. In general, if there is a choice of counter styles it is advisable to select the one having the sturdier construction, particularly for duty on continuous production.

Driving mechanisms for counters may be continuous or intermittent, depending on the type of counter and on what is to be counted. For continuously driven counters the simplest drive is a fork coupling consisting of two prongs which engage drilled

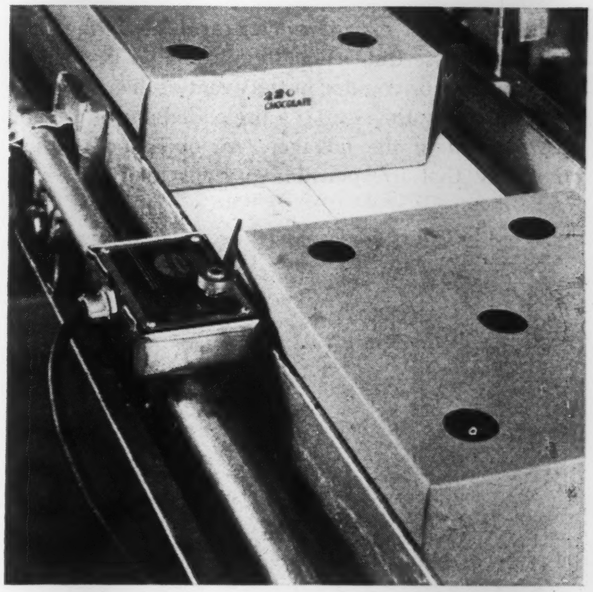
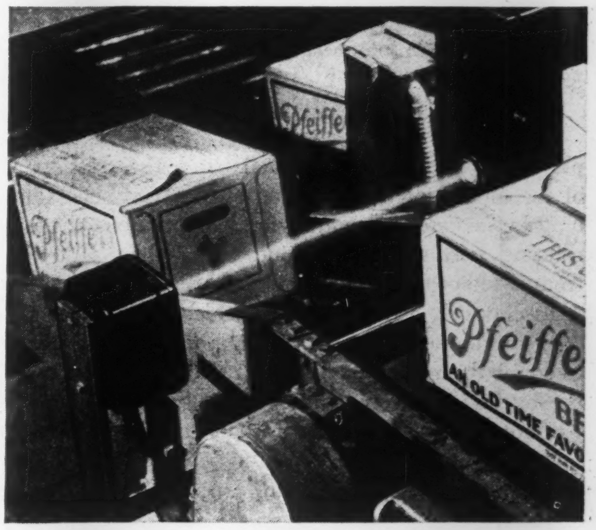


Fig. 7—Above—Switch actuated by cartons traveling on conveyor operates remotely located counter

Fig. 8—Below—Electric eye, operating through relay, actuates counter for cartons on a conveyor



holes in the end of the driving shaft. Flexible couplings, universal joints, gears, chains (*Fig.* 5), etc., may also be used. The most important consideration is the avoidance of excessive radial load on the counter spindle. For example, in one application serious trouble resulted from the use of a step-up gear with too small a pinion on the counter spindle.

Intermittent drives, such as are required with oscillating ratchet counters, employ an arm attached to the counter spindle. This arm may be operated by a linkage, as in *Fig.* 4, by a cam, as in *Fig.* 2, or directly by the part to be counted, as in *Fig.* 6. It will be noted that the carton counter shown in *Fig.* 6 employs a specially shaped piece bolted on to the standard lever furnished with the counter itself.

Precautions in Designing Linkage Drives

With a linkage it is desirable to provide some adjustment so that the correct angle of oscillation is given to the counter, avoiding undertravel (less than 36° with a 10-tooth ratchet) or excessive overtravel, obviating the necessity of too-close dimensional control. To prevent damage to the linkage or counter in the event of overtravel (beyond the limit set by the stops), a preloaded spring is sometimes incorporated in the linkage. An objection to this is the possibility that irresponsible persons may be tempted to play with the counter and make it register independently of the motion of the machine. Danger of such tampering may be lessened by employing a continuous drive from a rotating part of the machine rather than a stroke drive from a reciprocating or oscillating part.

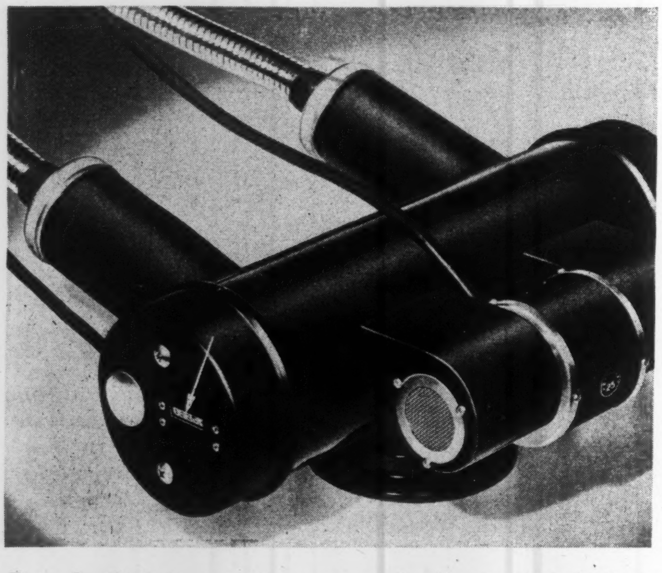


Fig. 9—Built-in counter, magnetically actuated from motor-generator circuit, records the number of times that the x-ray tube has been fired

In choosing a location from which to operate a counter on a production machine it is important, if at all possible, to count the pieces themselves rather than to count simply the cycles of the machine, which often can be operated without producing pieces. Good examples are clearly illustrated in *Figs.* 3 and 6. Incidentally, *Fig.* 3 illustrates the use of a star wheel in conjunction with a geared counter.

For remote location of the counter wheels with respect to the point at which measurement is made, magnetic or electric counters are preferred to mechanical drives. Inasmuch as the power to operate the electrical contacts is considerably less than that required to turn the counting mechanism, the magnetic counter is equivalent to a relay or power amplifier, and may be used in applications where insufficient force can be exerted to turn the counter. With a photo-electric relay, *Fig.* 8, no contact of course is necessary with the pieces to be counted, and minute parts or freshly painted articles can readily be counted.

Power to operate a magnetic counter ranges from 5 to 18 watts (momentary), which in most cases is more than the output of a phototube, hence in such applications an additional relay is necessary. An important factor limiting speed of operation is the necessary time of contact. For the average counter this should be not less than 1/20-second in order to complete the movement of the counting wheels. An additional minimum time of 1/20-second is necessary between contacts to allow the mechanism to return under the action of the spring. On the basis of these figures, maximum counting rate with a magnetic counter is about 10 per second or 600 per minute. Preferably the current should be off the counter when not operating, and high voltage should be avoided. The counter shown in *Fig.* 9, which is built into an x-ray tube, is energized each time the tube is fired. Ordinarily, any suitable design of cam switch or limit switch may be employed to do the actual counting. As in the case of the counters themselves, the sturdier the construction of the switch, the more the likelihood of long, trouble-free operation.

Where Power Absorbed Is Important

Although for most applications the power to operate the counter mechanism is of no importance, in some cases such as instruments or computing mechanisms the available power is quite limited. The torque required at transfer points may then be a serious consideration, necessitating the employment of lightweight low-friction counters for such service.

In conclusion, before making his final selection of a counter, the designer should avail himself of the engineering service offered by the counter manufacturer. By furnishing the manufacturer with complete information concerning the application—particularly operating speed, torque available (if limited), required size of figures, expected service life, ambient temperature, and environment—the designer can be assured that the counter will be up to the standard of engineering provided in the rest of the machine. Consideration of the counter early enough in the design to permit adequate housing will contribute to neat appearance.

MACHINE DESIGN acknowledges with appreciation the cooperation of the following companies in the preparation of this article.

The basic information furnished by Veeder-Root Inc. was particularly helpful.

Automatic Electric Co.	Chicago
Durant Mfg. Co. (*Figs.* 3 and 5)	Milwaukee
The National Acme Co.	Cleveland
Production Instrument Co. (*Figs.* 7 and 8)	Chicago
F. B. Redington Co. (*Fig.* 6)	Chicago
Veeder-Root Inc. (*Figs* 1, 2, 4 and 9)	Hartford, Conn.

MACHINE *Editorial* DESIGN

Renewed Challenge to Design

RECENTLY adopted wage-price policies may seem, at first glance, to be far removed from design. That they bear a definite relationship, however, can be easily recognized if consideration is given to the possibility of spiraling, such as might result from lack of design developments of the type now needed to facilitate manufacture and to increase the rapid flow of new goods.

Production and sale to the full extent of the nation's capacity will be essential if the trend toward inflation set up by the new rulings is to be held in check. With the heavily pent-up demand and, coupled with it, the current low production, it is clear that prices of goods will tend to soar much farther in the next few years than has been the case even in the relatively short time since V-J Day.

Governmental price controls, effective as they were during the war period, cannot be expected to serve a useful purpose for long in the peacetime economy without retarding the return to normal and prosperous conditions. Free and untrammeled competition is desirable, primarily because production is unlikely to reach its full stride under a system governed by continuous price ceilings.

To enable such controls to be relaxed insofar as manufactured goods are concerned, and at the same time to aid in resisting the inevitable trend toward rising prices, the engineer responsible for design now has the opportunity of increasing still further the prestige that came to him as a result of wartime achievements. Additional recognition should come his way through demonstration of his ability to change his thinking again in regard to the question of cost as a primary factor in design. Whereas this factor was negligible in most cases in the design of equipment manufactured during the war, it now assumes a position of top-rank importance.

In respect to consumer goods, in particular, the cost element is vital. As far as manufacturing equipment is concerned, however, initial cost necessarily must be subordinated to high production capacity to offset the current and prospective high labor rates.

All in all, the design profession is confronted with a challenge that will tax the ingenuity of its individual members to a marked degree. They can be relied upon to "put design for production first" and not to miss any opportunity within their power of combating the prospective threat to the national economy.

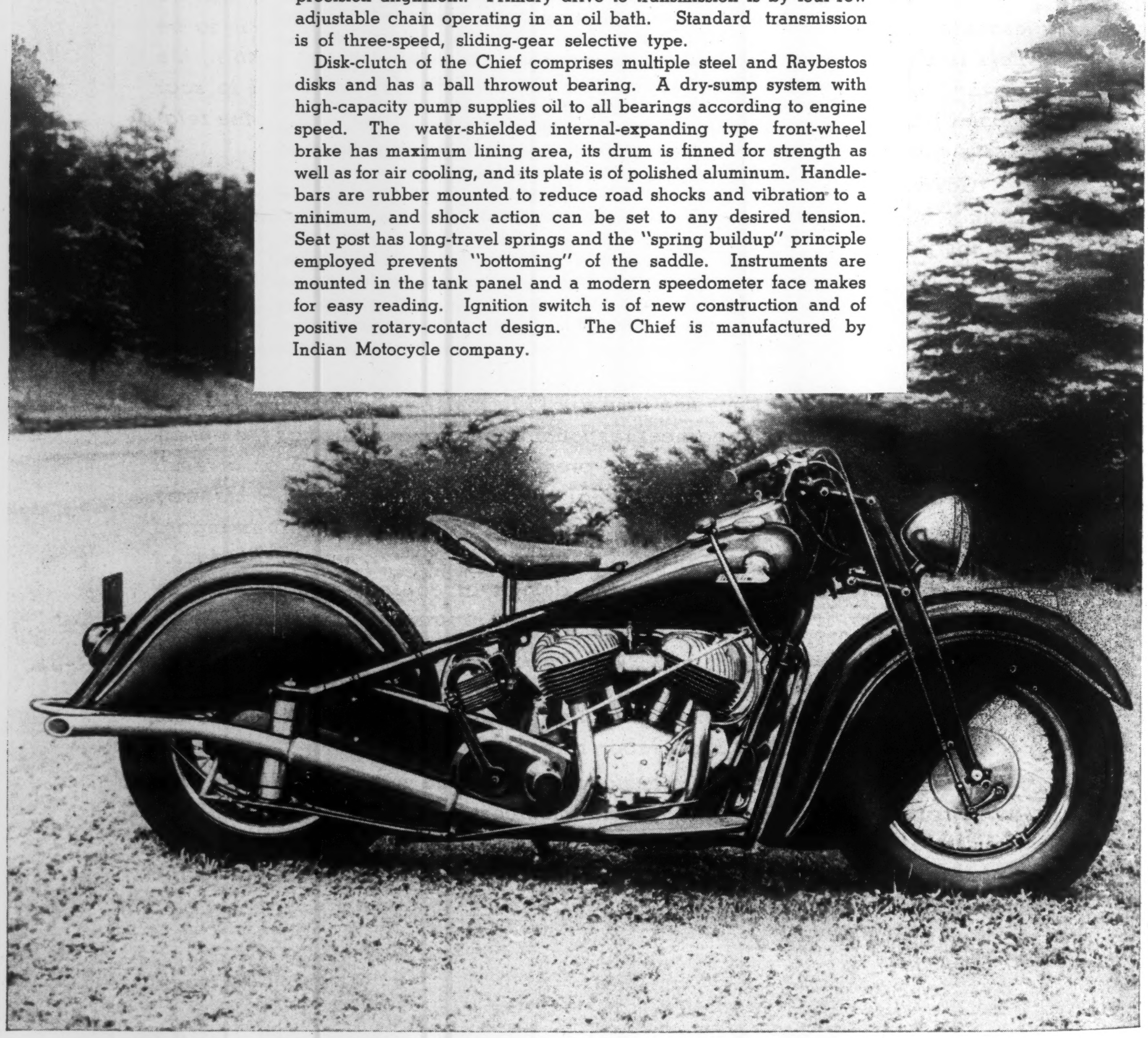
L. E. Jermy

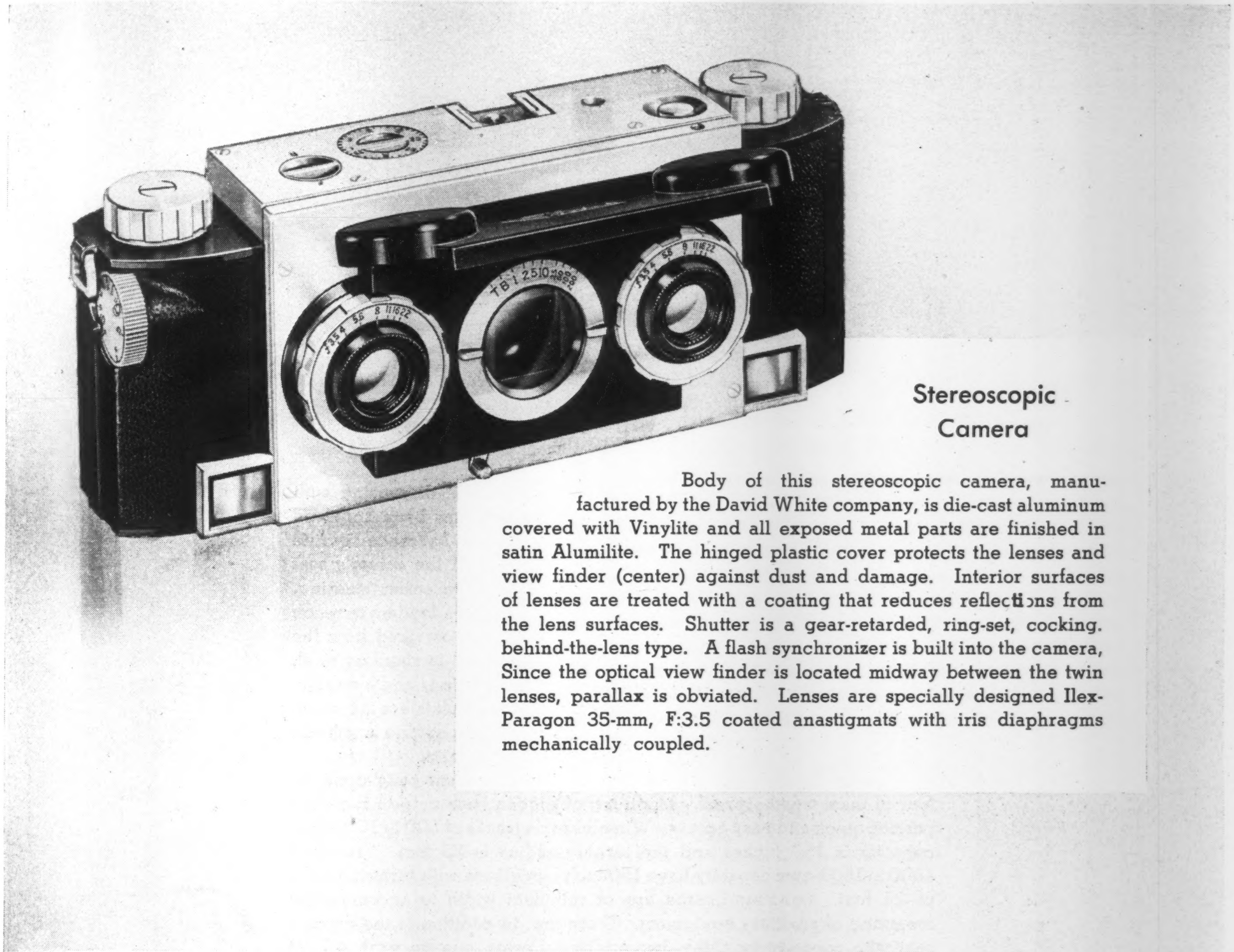
Outstanding Designs

1946 "Chief" Motorcycle

Most notable innovation in the 1946 "Chief" is the new dual-spring front fork with hydraulic shock absorber which saw original service in military motorcycles of the war. A two-cylinder, 42-degree V-type, L-head, air-cooled engine is used. Its connecting-rod holes are diamond bored and ground in one operation to insure precision alignment. Primary drive to transmission is by four-row adjustable chain operating in an oil bath. Standard transmission is of three-speed, sliding-gear selective type.

Disk-clutch of the Chief comprises multiple steel and Raybestos disks and has a ball throwout bearing. A dry-sump system with high-capacity pump supplies oil to all bearings according to engine speed. The water-shielded internal-expanding type front-wheel brake has maximum lining area, its drum is finned for strength as well as for air cooling, and its plate is of polished aluminum. Handlebars are rubber mounted to reduce road shocks and vibration to a minimum, and shock action can be set to any desired tension. Seat post has long-travel springs and the "spring buildup" principle employed prevents "bottoming" of the saddle. Instruments are mounted in the tank panel and a modern speedometer face makes for easy reading. Ignition switch is of new construction and of positive rotary-contact design. The Chief is manufactured by Indian Motocycle company.





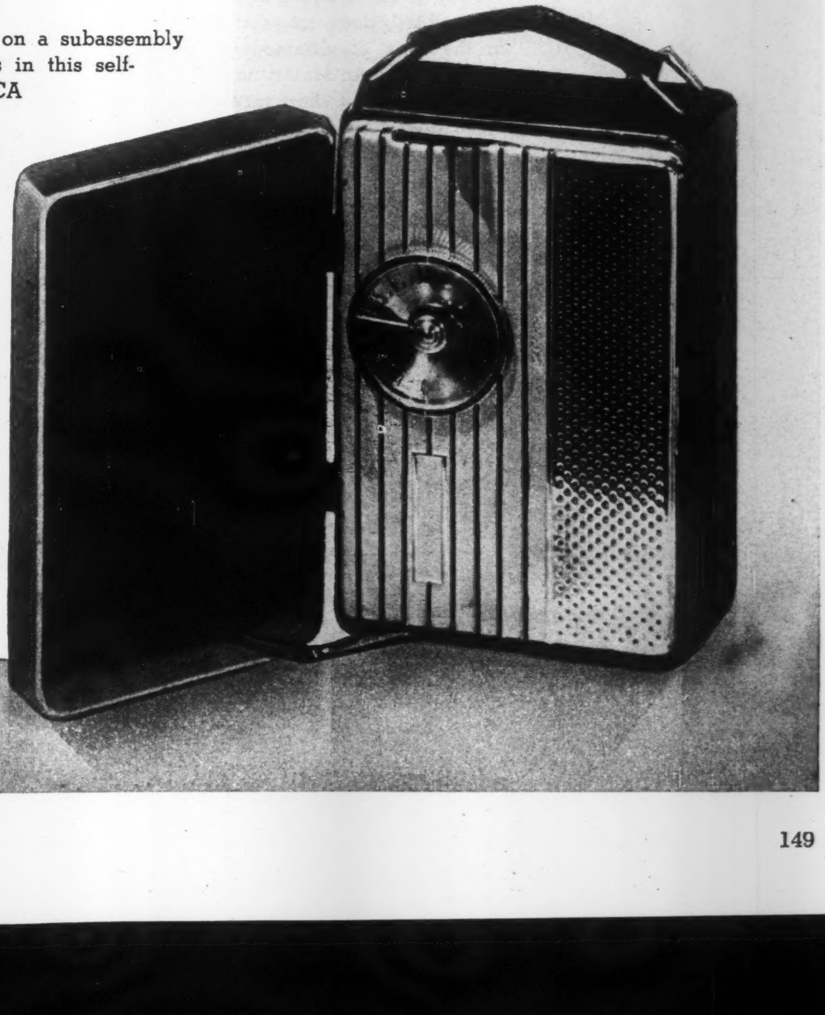
Stereoscopic Camera

Body of this stereoscopic camera, manufactured by the David White company, is die-cast aluminum covered with Vinylite and all exposed metal parts are finished in satin Alumilite. The hinged plastic cover protects the lenses and view finder (center) against dust and damage. Interior surfaces of lenses are treated with a coating that reduces reflections from the lens surfaces. Shutter is a gear-retarded, ring-set, cocking. behind-the-lens type. A flash synchronizer is built into the camera, Since the optical view finder is located midway between the twin lenses, parallax is obviated. Lenses are specially designed Ilex-Paragon 35-mm, F:3.5 coated anastigmats with iris diaphragms mechanically coupled.

Personal Radio

Four miniature tubes are employed on a subassembly flexibly mounted to the major chassis in this self-operating personal radio built by RCA Victor. A superheterodyne circuit is used, giving exceptional sensitivity and selectivity. Sound is produced by a miniature permanent-magnet electrodynamic loudspeaker using the new Alnico 5 magnet material.

Bezel and dial are chromium plated and center portion of case is a die-cast zinc alloy, lacquer finished. Top and bottom covers are molded polystyrene with an alligator grain copied from a section of actual alligator skin. Polystyrene was selected for its stability, strength and exceptional electrical characteristics, required because the loop aerial is mounted in the lid.

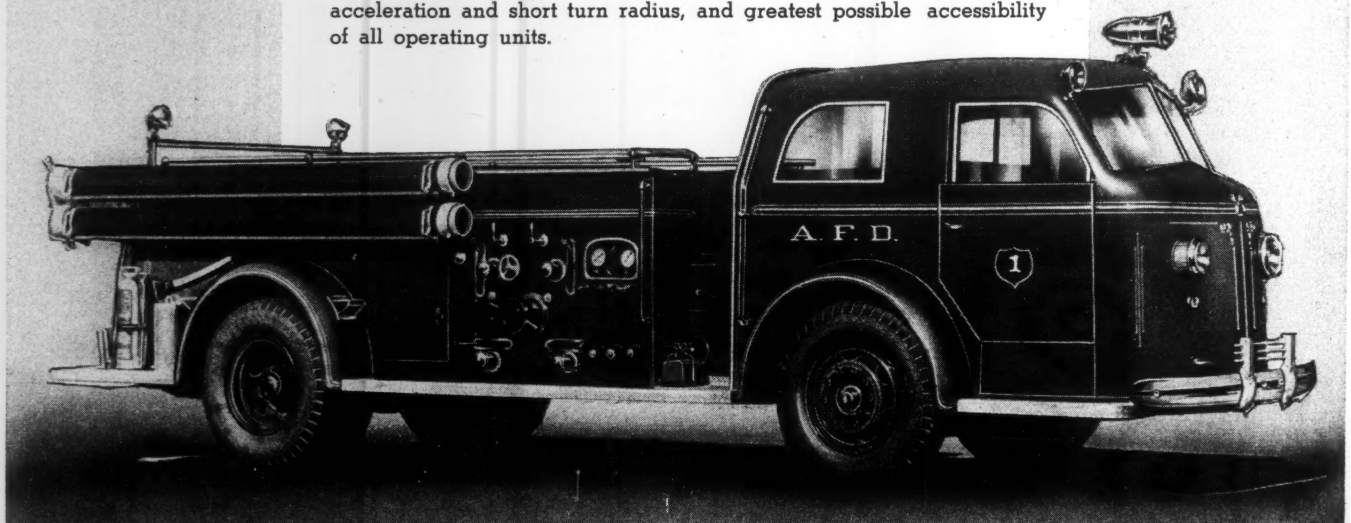


Fire Engine

By placing the driver's compartment up front and dispensing with the familiar long engine hood, maximum visibility has been achieved in this new fire engine manufactured by American-LaFrance-Foamite Corp. Location of the engine and radiator back of the driver's seat permits better weight distribution and contributes to easier steering. Engine is readily accessible from the side with no wide fenders to reach over and no paint finish to mar with tools. Pump is serviced from the top. Its housing and impellers are bronze and shaft is stainless steel. The pump has automatic packings, replaceable seal rings and a double-suction impeller for the first stage. Three suction inlets are provided for the two impellers. Priming system on the pumping engine is exhaust ejector type employing no gears or other rotating parts.

Utility is provided by the use of five large equipment compartments, four of them weatherproof. Mounting of suction hose outside the body permits quick and easy access. Wheelbase on trucks of 500 to 1000-gpm capacity is 150 inches and the turning radius is 25 feet. Trucks of 1000 to 1500-gpm capacity have 160-inch wheelbase with turning radius of 27 feet. Running boards are of sufficient width to accommodate mounting of auxiliary equipment. There are, in addition to the driver's seat with capacity for three, two additional seats, one on each side of the motor, facing rearward.

Here is an example of modern design which, while conservatively streamlined, does not sacrifice operational ease, accessibility or utility or the sake of ultramodern styling. Factors stressed in design development were: Maximum visibility for driver, maximum utility, high acceleration and short turn radius, and greatest possible accessibility of all operating units.

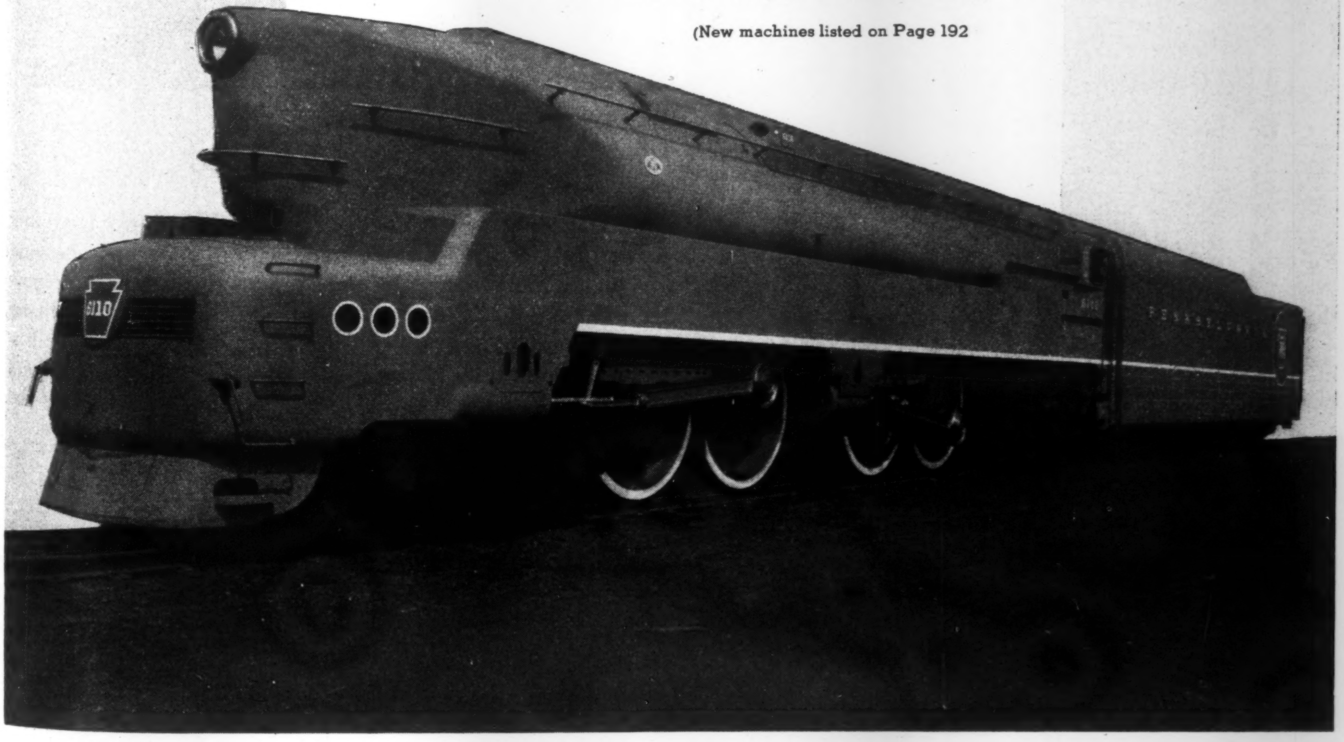


Streamlined Steam Locomotive

This four-cylinder steam locomotive built by The Baldwin Locomotive Works and designated the T-1, has a one-piece bed cast of 2¼ per cent nickel steel and utilizes a high percentage of alloy steels in working parts to obtain optimum unit strengths at minimum weight. For example, main and side rods, as well as lightweight reciprocating parts, are forged from nickel-chromium-molybdenum steel (modified SAE 4340), heat treated to provide high strength and toughness. Boiler is of conventional internally-fired, fire-tube type and operates at 300 pounds working pressure. Plate for boiler and firebox is 2 per cent nickel, low-carbon steel. Belpaire-type firebox used permits generous steam space, good stress distribution, extensive firebox heating surface, and excellent resistance to distortion in service.

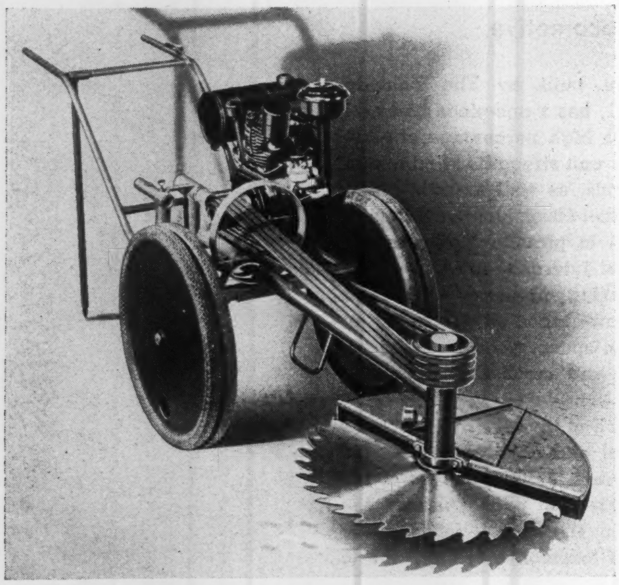
Cylinder valves are poppet type. Each of the four cylinders has a steam chest at both ends of the barrel and each chest contains two 5-inch admission valves and two 6-inch exhaust valves of the horizontal double-seated type. Eight valves of each cylinder are operated through a cam-box located in the space between the steam chests. Machine efficiency of the locomotive is high due to the poppet valves and roller bearings on driving rods, truck journals, and crossheads. Forced-feed oil lubrication is provided for eighty-eight other vital points. Efficiency exceeds 90 per cent at all speeds and horsepowers, with a high of 97.5 per cent at 38 miles per hour and 4500 horsepower. Maximum indicated horsepower, reached at 85.5 mph, is 6552. Driving wheels are 80 in.; truck wheels are 36 in. at front and 42 in. at back. Wheel base of locomotive, less tender, is 51 ft. 11 in. Streamlining was done by industrial designer Raymond Loewy.

(New machines listed on Page 192



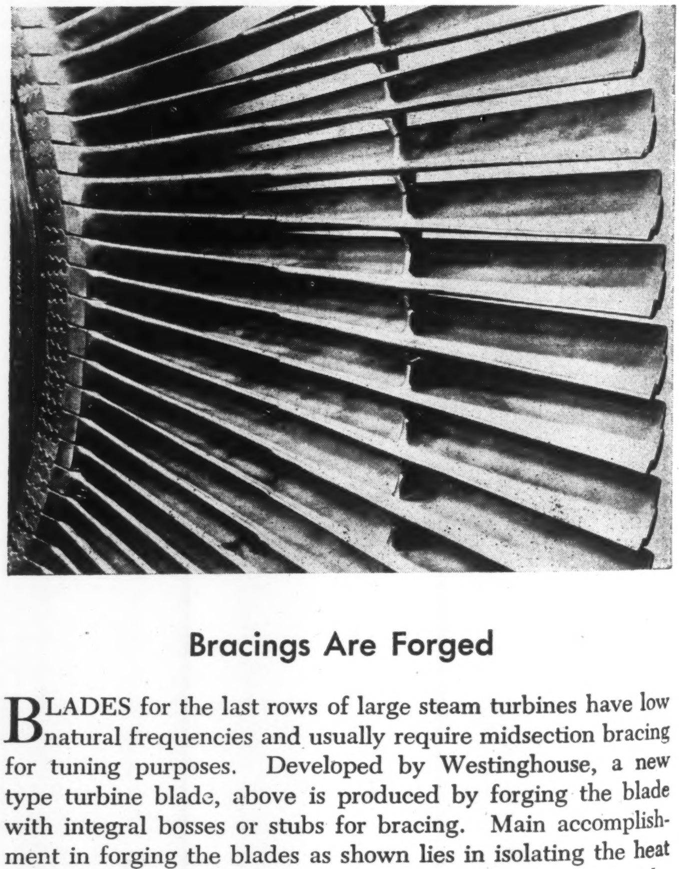
Applications

of Engineering Parts, Materials and Processes



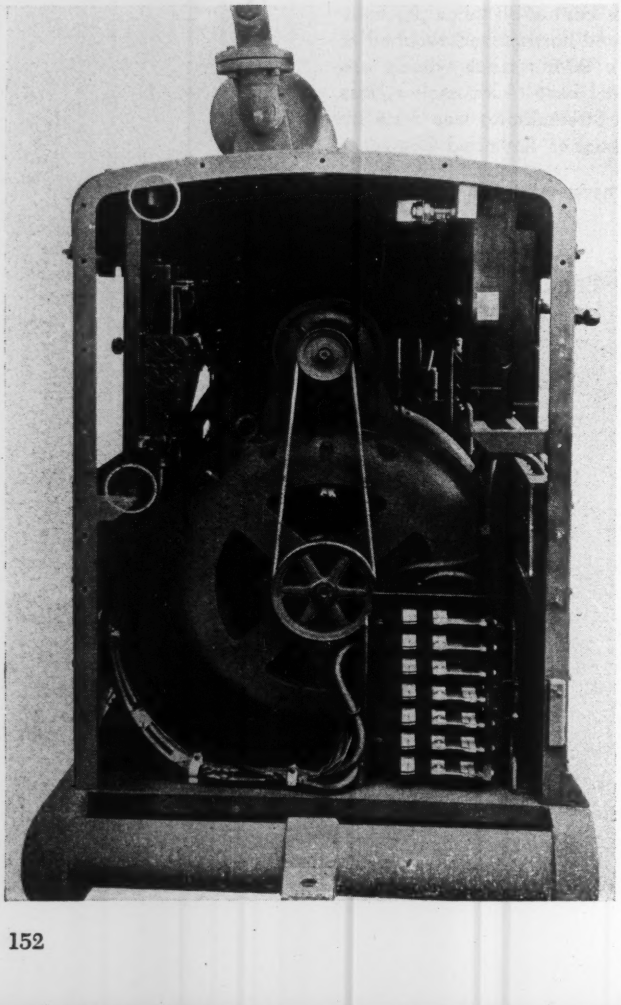
Steel Tubing

STEEL tubing provides a simple, neat appearing and sturdy frame for the Lowther C-Saw, left, capable of cutting through a 24-inch hardwood tree in less than three minutes or 11 inches of spruce in seven seconds. Use of tubular members makes possible a mounting which can be adjusted to any required angle while the belt drive remains on constant centers.



Bracings Are Forged

BLADES for the last rows of large steam turbines have low natural frequencies and usually require midsection bracing for tuning purposes. Developed by Westinghouse, a new type turbine blade, above is produced by forging the blade with integral bosses or stubs for bracing. Main accomplishment in forging the blades as shown lies in isolating the heat created in welding adjacent bosses and thus protecting the metallurgical structure of the blade material.



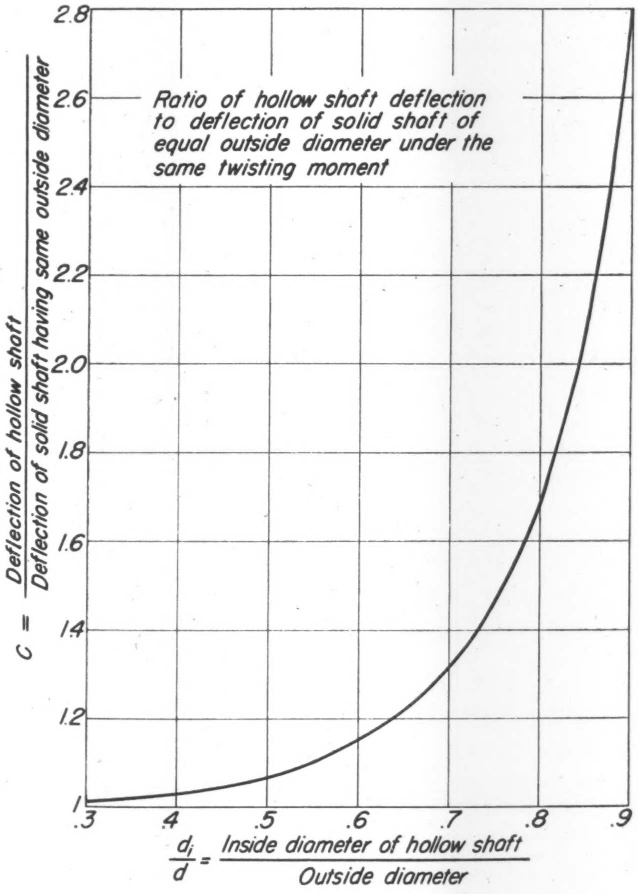
Insulates Instruments

TO INSULATE the instruments of this motor-generator set, left, from any deleterious vibrations, the instrument panel is mounted on four Vibro-Insulators—devices of rubber and metal made by the B. F. Goodrich Co. Indicated by the circles in the photograph, two bottom insulators support the 49-pound panel in shear and two at the top in compression.

Calculating Torsional Stiffness of Shafts

By Colin Carmichael
Associate Editor, Machine Design

BECAUSE excessive angular deflection of shafts may lead to bearing difficulties and to torsional vibration trouble, the designer should check the torsional stiffness after determining the provisional shaft diameter for strength (see M.D., Sept., 1945, Page 149). The nomographic chart which appears on the next page of this Data Sheet facilitates the quick solution of angle of twist and may be used in determining shaft stiffness constants for the solution of torsional vibration problems.



Basic equation relating torsional moment, angle of twist, and shaft dimensions for a solid round shaft is

$$\frac{T}{\theta}=\frac{\pi d^4 G}{32l} \qquad (1)$$

where T = torsional moment, in.-lb; θ = angle of twist, radians; G = torsional modulus of elasticity = 11,800,000 psi for steel; d = shaft diameter; and l = length of shaft, in. If the angle of twist is to be measured in degrees, α, the equation may be written

$$\alpha=0.0000495\frac{Tl}{d^4} \qquad (2)$$

The chart solves Equation 2 for a twisting moment T = 1000 in.-lb. Denoting the twist angle for 1000 in.-lb twisting moment by a,

$$a=0.0495\frac{l}{d^4} \qquad (3)$$

which is the basis of the chart. Actual twist for torque T therefore is

$$\alpha=\frac{aT}{1000} \qquad (4)$$

While no hard-and-fast rule can be stated for permissible deflection, a twist of 1/10-degree per foot length is sometimes considered the limit. For the same maximum stress small shafts will, of course, deflect more per foot length than larger shafts. When in doubt, a torsional vibration investigation is desirable.

EXAMPLE: It is required to determine the twist in 2-in. diameter shaft, 15 in. long when subjected to a torsional moment 12,000 in.-lb. Referring to the chart on the next page, a computing secant is laid across the value l = 15 in. on the left-hand scale and d = 2 in. on the middle scale. Extension to the right-hand scale gives the value a = 0.046. Actual angle of twist, from Equation 4, is α = 0.046 × 12,000/1000 = 0.552 degrees.

For a stepped shaft the total twist is simply the sum of the twists for each section, or

$$\alpha=(a_1+a_2+a_3+etc.)\ \frac{T}{1000} \qquad (5)$$

In torsional vibration calculations[*] the shaft stiffness constant, k (in.-lb per radian), is a controlling factor. Inasmuch as $k = T/\theta$, Equation 1 gives this constant in terms of shaft dimensions. Since there are 57.3 degrees in a radian, the stiffness constant may be written

$$k=\frac{57.3T}{\alpha} \qquad (6)$$

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[*] See the Data Sheet "Calculating Natural Frequencies of Torsional Vibration," MACHINE DESIGN, May 1943, Page 119.

ENGINEERING DATA SHEET

Substituting for T and α from Equation 4

$$k=\frac{57300}{a} \quad \text{(7)}$$

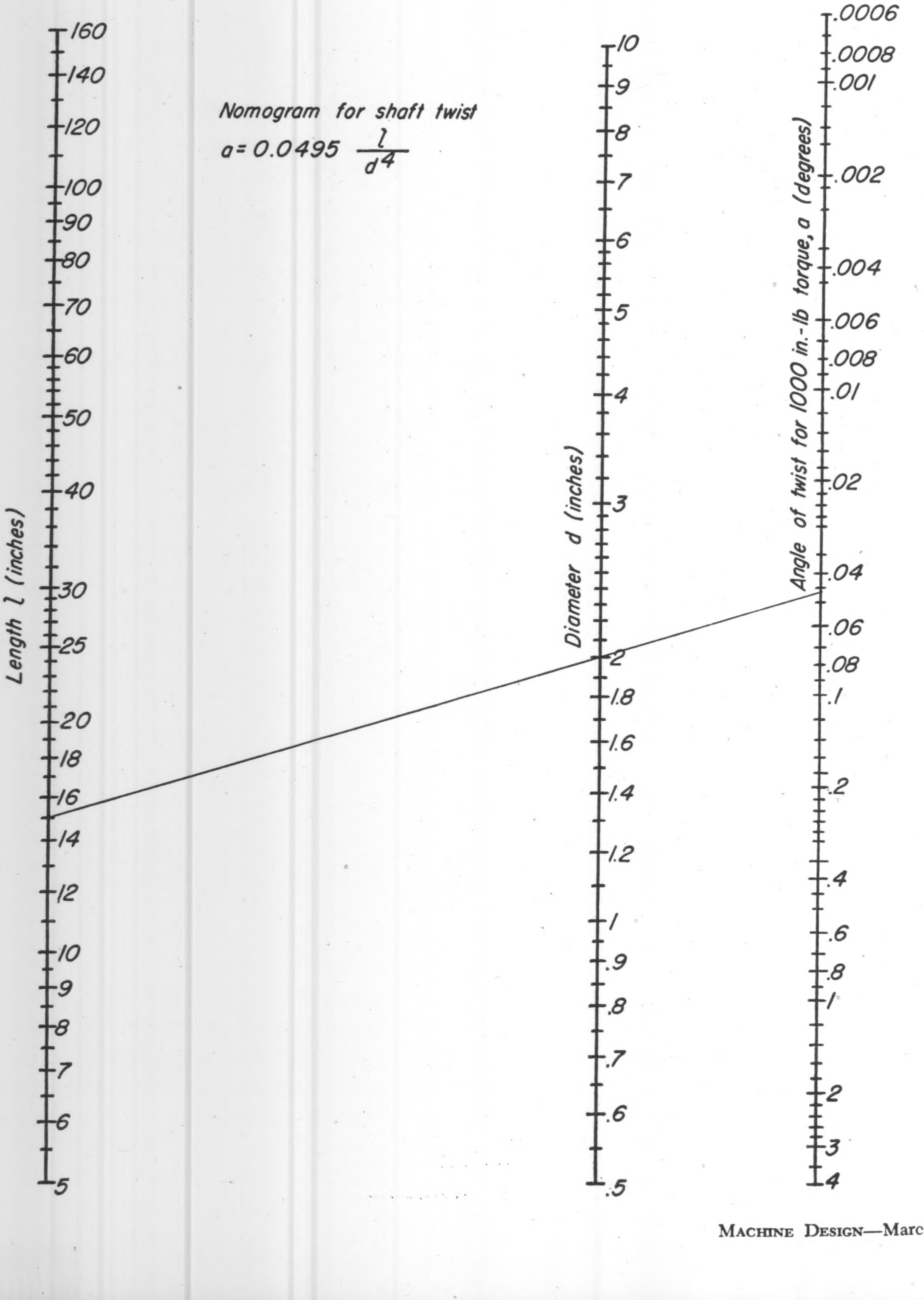
For a stepped shaft the effective value of k is

$$k=\frac{57300}{a_1+a_2+a_3+etc.} \quad \text{(8)}$$

Hollows shafts may be dealt with by means of a correction factor which is the ratio of the deflection of a hollow shaft to that of a solid shaft of the same outside diameter. This ratio is

$$C=\frac{d^4}{d^4-d_i^4}=\frac{1}{1-\left(\frac{d_i}{d}\right)^4}$$

where d_i = inside diameter of the hollow shaft. Values of the correction factor may be obtained from the curve sheet on the previous page.



Design Abstracts

Design Economics of Magnesium

IF THE designer is not aiming at maximum weight saving and does not have certain space limitations, then he can use the extra volume of magnesium metal at his disposal, without a weight penalty, to *simplify* design and construction by increasing sections and eliminating the usual ribs and stiffeners. Such design has several service characteristics of importance, but that it has direct consequences in lowering the *cost* of an article is perhaps only beginning to be realized.

A good illustration of the principle can be seen from the figures on the magnesium floor beams used in cargo ships built by Douglas Aircraft. Magnesium extruded I-beams in this application have been standard for some years, having replaced the previously used fabricated aluminum I-beams. The aluminum beam was made up from sheet for the web riveted to angles for the flanges and with many riveted cross members for additional stiffness, all requiring manhours of labor. In magnesium the thickness of web and flange were increased about 50 per cent, which made extrusion of the complete I-beams at a good rate entirely feasible, thus substituting a single extrusion operation for the highly paid shop labor required on aluminum beam fabrication. The Douglas Aircraft Co. stated that the finished magnesium beam was 25 per cent cheaper, 35 per cent stronger and 5 per cent lighter.

Another example from the aircraft field is a 60-pound stabilizer of magnesium. This is a case in which the magnesium design does not aim at weight saving but rather uses greater thickness of metal in the skin structure and thus avoids the necessity of complicated and expensive construction. The aluminum stabilizer cost $40.00 for material and $191.00 for labor, while the magnesium stabilizer cost $62.00 for material but only $78.00 for labor.—*From an address by Dr. J. D. Hanawalt, director, metallurgical department, The Dow Chemical Co., given before a recent meeting of the Engineering Society of Detroit.*

Hydraulic Accumulators for Aircraft

ONE element of aircraft design made particularly difficult by the problem of weight is that of the accumulator. Extensive research and experimentation have gone into the development of what seems a simple device, but in reality is fraught with complications. A standard industrial accumulator, adapted to meet the rather specialized needs of aircraft, would weigh over six tons.

Serving about the same purpose in a hydraulic circuit as a storage battery in an electric circuit, an accumulator provides storage of fluid under pressure as potential energy for momentary delivery to the system, supplementing delivery from the pump, and absorbing pulsations.

Satisfactory solution of the problem involved a gradual bettering of accumulator design, starting with the simple addition of an accumulator to the hydraulic circuit. Subsequent step-by-step improvements include:

1. The addition of a check valve enables the accumulator to maintain pressure on the hydraulic system when the pump has stopped operation.
2. With an unloading valve acting as a pressure regulator, pump delivery continues, but by-passes the accumulator when it is fully charged, and returns to reservoir.
3. The hydropneumatic accumulator employs expanding gas to displace hydraulic fluid; although favorable for aircraft applications, it necessitates separation of air and oil, since oils used have an affinity for air.
4. Floating piston, used to some extent as a separating agent in cylindrical accumulators, has disadvantages of excess weight and size, friction of seals on pistons, and possibility of leakage from the wear of the seals.
5. Bag type of accumulator contains a bag which expands as fluid is discharged from the accumulator, contracts as accumulator is charged with fluid.
6. For maximum strength and minimum weight the spherical accumulator offers the best arrangement for aircraft use. It has additional qualities of minimum over-all dimensions, maximum displacement, and maximum life in all types of aircraft service. A pliable synthetic diaphragm prevents external leakage and mixture of air and oil, and is flexible within the range of −65 F to 160 F.

Standard accumulators of 5, 7½, and 10 inches in diameter cover the requirements of almost every aircraft hydraulic system. A combination of sizes may be used for any required volumetric capacity. However, a 10-inch accumulator, for instance, is equivalent to eight five-inch accumulators; since the 10-inch model weighs only half as much as the combination, use of a larger accumulator is preferable from the weight standpoint.—*From a paper by K. C. Monroe, Vickers Inc., presented at a recent meeting of the Southern California Section of SAE.*

Materials Work Sheets Reprints

Reprints of all Materials Work Sheets published in MACHINE DESIGN during 1945 have been mailed, free of charge, with this issue of the magazine. They are in loose-leaf form, suitable for insertion in the binder furnished with previous reprints. The following price schedule applies to additional sets of the 1945 reprints:

Quantity	Price, Ea.
1 set	$.50
2-9 sets	.45
10-24 sets	.40
25-49 sets	.35
50 or more sets	.30

Orders should be sent to Readers Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, O., and a 3% state tax included for those originating in Ohio.

In the future, Materials Work Sheets will be published every other month, the material scheduled for coverage in April being Nickel, in both the wrought and cast forms. No Work Sheet appears in this, the present issue.

ASSETS to a BOOKCASE

Evaluation of Effects of Torsional Vibration

Published by the Society of Automotive Engineers Inc., New York; 576 pages, 8½ by 11 inches, clothbound, available through Machine Design, *$5.00 to S.A.E. members, $10.00 to nonmembers postpaid.*

Originally prepared in response to a request from the Navy, this report from a special committee of the SAE War Engineering Board forms an interesting fundamental treatise on torsional vibration. Engineers, machine designers and research men confronted with torsional vibration problems will find the experimental and analytical methods for investigating, and means for controlling such vibrations of great value. This free exchange of practical engineering information representing a large number of industrial sources, though not necessarily in total agreement, constitutes a vital element in the progress of machine design.

In the introduction the problems and final conclusions are set forth. Experimental methods used for measuring torsional vibration and methods for determining and estimating the significance of nominal torsional stresses, are outlined as well as means for reducing them. Characteristics of well known conventional torsional vibration measuring equipment are discussed and compared. Unique types of torsiographs and calibrators are also presented.

Attention is given to various short-cut methods for calculation of natural frequencies and also to methods of experimental determination by electrical and mechanical analogy. Experimental procedure for fatigue testing of full-scale parts is covered by several reports including diagrams and photographs of fatigue equipment now in use.

□ □ □

Industrial Process Control

By Donald P. Eckman, engineering department, The Brown Instrument Co.; published by John Wiley & Sons, Inc., New York; 230 pages, 5½ by 8⅜ inches, clothbound; available through Machine Design, *$3.50 postpaid.*

Material in this book represents a collection, coordination and expansion of the most recent information on automatic control based on practical experience and backed up by factual data and concrete examples. Automatic positioning controllers have met with great success in the rapid and accurate control of airplanes, guns, industrial machinery, etc. Automatic control of industrial processing, a new tool for the designer, is assuming greater importance in improving and speeding up the production of many present-day engineering materials.

The author of this book offers a thorough treatment of the theory of automatic control including studies of controlled and uncontrolled process response curves. The aim of the book is to make available to the engineer the underlying factors with which he must be familiar if he is to handle industrial control mechanisms successfully.

Covered in a comprehensive manner are: Measuring characteristics of controllers, controller characteristics, the effect of process load changes, the effect of valve characteristics, and correlated or multiple-control systems. Various types of controllers such as pneumatically and electrically-operated valves, dampers, and louvers are detailed along with a description of their characteristics and principles of operation. The meaning of measurement in automatic control and the problems of lag are dealt with as well as many other subjects of equal importance. This aid to the proper understanding of the basic principles of automatic control should prove of great value in the analysis of everyday problems in this field regardless of variations in physical or mechanical details.

□ □ □

Fundamental Theory of Servomechanisms

By LeRoy A. MacColl, member of the technical staff, Bell Telephone Laboratories, Inc.; published by D. Van Nostrand Co., Inc., New York; 128 pages, 6 by 9 inches, clothbound; available through Machine Design, *$2.25 postpaid.*

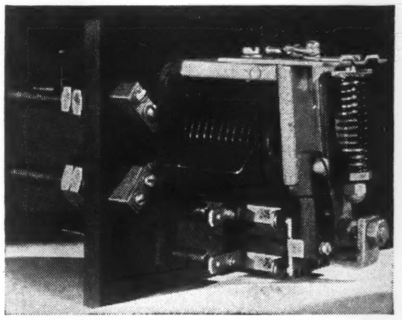
Thorough analysis and competent design of a modern servomechanism of satisfactory stability and high dynamic accuracy is a problem engineers seldom find a simple one. In a broad and fundamental approach to the subject of servomechanisms, the author of this book presents the theory which furnishes one unified method for analyzing or designing such units.

Concerned primarily with the general theory applicable to all linear continuously operating servomechanisms, this interesting aproach to the subject is made entirely by means of the methods developed by communications engineers. The various chapters cover elements of the steady-state theory, the theory of transients in linear systems, stability, performances, complicated feed-back paths, alternating-current motors and oscillating controls, sampling servos, etc. Although certain particular systems are described and discussed briefly for illustrative purposes, no attempt is made to deal with the multitude of complications involved in the practical design of the various mechanisms. Regardless of whether a servo is of the mechanical, electrical, hydraulic, or pneumatic type, underlying mathematical theory is essentially identical and the unified approach outlined makes a lucid, stimulating mathematical study.

NEW PARTS AND MATERIALS

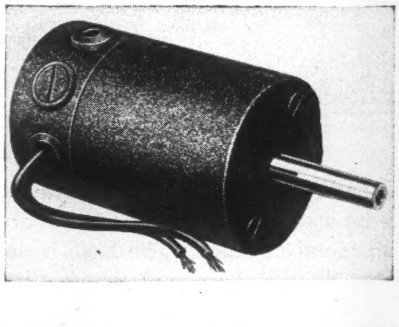
Magnetic Overload Relay

A NEW TYPE AYJ relay for d-c operation, announced by Westinghouse Electric Corp., Pittsburgh, provides almost instantaneous magnetic overload protection and prevents damage to equipment. The single-break normally-closed main contacts and the double-break auxiliary contacts are suitable for carrying 5 amperes continuously and for interrupting a d-c inductive coil load of 150 volt-amperes maximum. These relays are operated by a series or copper strap wound type of coil. Coils and coil studs are available for currents ranging from approximately 75 to 625 amperes. The coils and auxiliary contact parts are insulated from the relay frames for 600 volts.



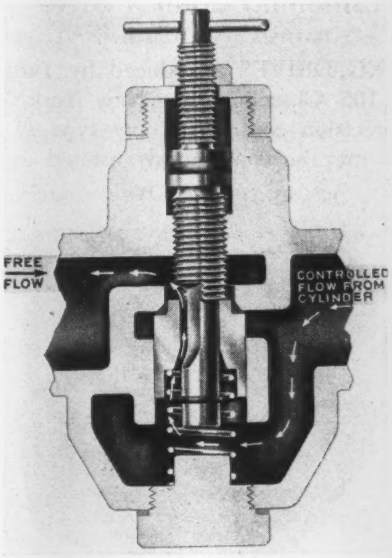
Lightweight Precision Motors

WEIGHING 11 oz and developing 1 inch-oz torque at 8000 rpm and 4 inch-oz locked torque (8000 rpm), a new ac-dc electric motor known as Model DS-105 is being offered by Electro-Engineering Industries, 800 N. Clark St., Chicago. Body dimensions of the motor are 1.687 x 2 9/16 x 1/4 inch. On specification, a special governor is available which makes possible refinements in speed control—accuracy to within 0.25 per cent. For electronic applications requiring complete freedom from radio-frequency intereference, a condenser-type motor is offered. Small, permanent-magnet motors are also available. Motors are wound for 6 to 115 volts, and have sealed ball bearings, die-cast housing, ground cores, and laminated fields. Specially designed motors up to 1/4-hp are being made available by the company to meet individual size and performance specifications.



Speed Control Valves

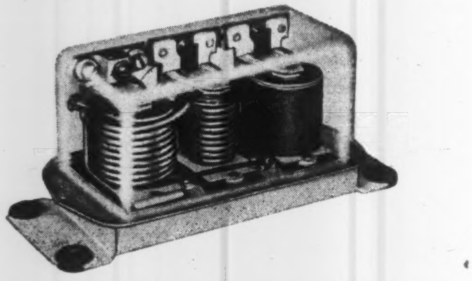
AN UNLIMITED range of selectivity in volume of air, giving quick control of piston speed, is provided by the speed-control valve offered by Ross Operating Valve Co., 6485 Epworth Blvd., Detroit 10. Flow of air from cylinder to valve can be regulated in small or large volume. There are two moving parts—stem and poppet—in the valve with the stem shaped to form a venturi for the passage of air in small volume. As the threaded stem is turned downward from a closed position, incoming air in small volume passes through the venturi into the outlet passage, increasing in volume as the stem is lowered. Continued turning causes a flange on the stem to open the



poppet, permitting further increase in volume to full flow. Return air is at full flow.

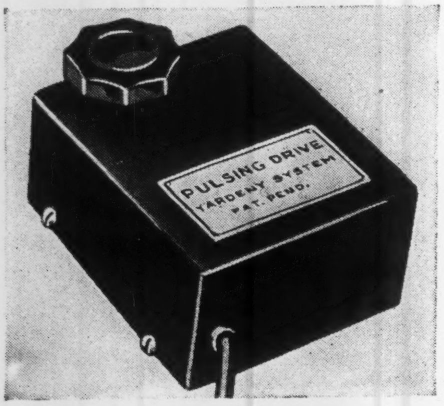
Heavy-Duty Voltage Regulators

SUITABLE FOR stationary or mobile gas engine or motor-driven generators, improved 3-unit, vibrating type, heavy-duty voltage regulators are now being produced by R-B-M Mfg. Co., Division of Essex Wire Corp., Logansport, Ind. All three units (reverse current relay, voltage control, and current limiter) of the regulator are designed to work in any position and withstand external vibration and shock normally encountered in mobile apparatus. Sealed in a gasketed, drawn-steel enclosure the regulators are available in maximum capacities of 30 amperes at 6 to 32 volts and 45 amperes at 6 to 12 volts direct current. Maximum field current rating is 3 amperes at 6 volts; 0.5 amperes at 32 volts direct current. Approximate dimensions are 7¾ x 4 x 3½ inches; weight, 3.25 lb.



Positioning Control Drive

POSITIONING DRIVES introduced by Yardeny Engineering Co., 105 Chambers St., New York 7, provide single-knob precision control for any type of reversible motors which may be continuously rotated or moved in small increments. Slow clockwise rotation of the knob results in corresponding motor motion, while a slow counterclockwise rotation causes reverse motor rotation. Rapid rotation of the knob causes faster motor motion and more extended travel. By depressing the knob and turning the knob slightly right or left, continuous forward or reverse rotation of the motor can be accomplished. The drive works on all standard current and frequencies, and is suitable for controlling valves, flaps, radio tuning elements, cranes, lifts, rollers, presses, machine tools, etc.



Roller Coating Process

METAL, WOOD and plastic products can now be finished before stamping, forming or other fabricating by a new method of roller coating developed by the Japan Co., 5103 Lakeside Ave., Cleveland. The new method produces roller coated sheets completely baked in three minutes or less. All types of coating are applied with uniformity of thickness, tolerances as close as 0.001-inch being held to customers' specifications, and uniform color shades, including delicate pastels, are maintained.

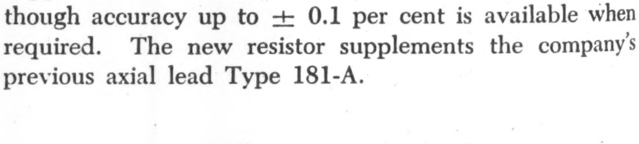
Fixed Wire-Wound Resistor

TO MEET THE need for a small, close-tolerance unit, Shallcross Mfg. Co., Jackson and Pusey Aves., Collingdale, Pa., has announced its fixed wire-wound resistor, rated at 1 watt with maximum resistance of 1 megohm and having axial loads for convenient mounting by the leads on standard terminal strips. Known as the Akra-Ohm Type 188, the new resistor is 1 3/16 inches long by ⅜-inch diameter. Axial leads are 3 inches long of No. 20 tinned copper wire. Standard tolerance is ± 1 per cent, although accuracy up to ± 0.1 per cent is available when required. The new resistor supplements the company's previous axial lead Type 181-A.

Shallcross
AKRA-OHM

Small Terminal Block

SPECIALLY DESIGNED for installations where it is necessary to conserve space, a new type of terminal block is being marketed by Curtis Development & Mfg. Co., One North Pulaski Rd., Chicago 24. Any number of terminals may be assembled, from one to twenty-four, and held rigid in a metal channel. The base is one solid insulator adjoining the metal channel as screw holes are not completely through the block. The new terminal blocks have ample clearance and creepage distances for circuits carrying up to 300 volts, 10 amperes. Because of its



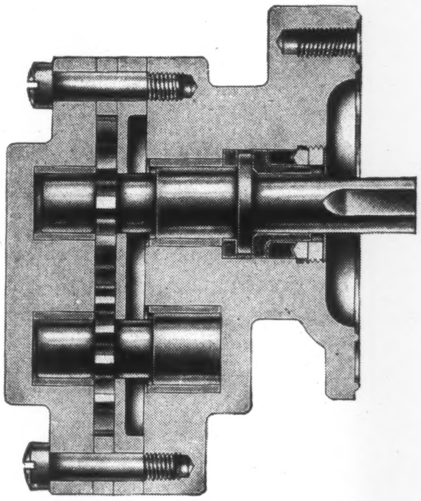
small size, this block known as Type M features a marker strip along the top of the desired length of terminals. The block can be supplied with or without the marker strip.

Insulated Electrical Wire

ELECTRICAL WIRE insulated with natural rubber latex is again being furnished for peacetime applications by United States Rubber Co., New York. Known as Laytex, the wire is insulated by running the conductor through a bath of liquid rubber, making the finished wire lighter in weight and smaller in diameter.

Rotary Pump

DESIGNED TO pump both heavy viscous materials or light volatile materials with a minimum of vapor lock, the new pump of Marco Co., Wilmington, Del., maintains volumetric efficiency due to being equipped with an automatic compensating wear control. It has a positive displacement and high vacuum. Shafts are equipped with a self-adjusting seal enclosed in steel armour. The smallest model, known as the Victor, needs no lubrication, while the other designs, called the Commander and Challenger, are equipped with automatic lubrication. Operating under high or low pressure, having a steady nonpulsating delivery, the pumps are built in various sizes and capacities. The smallest has a range of 5 to 300 gph and the largest, 1880 to 3765 gph. Other sizes can also be built to requirements.

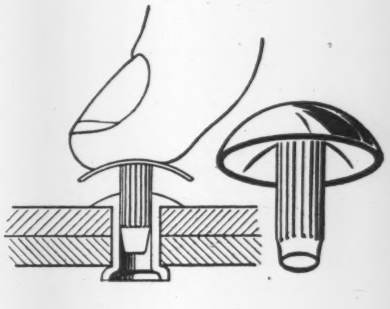


Shielded Arc Electrodes

SHIELDED ARC ELECTRODES of Ampco Metal Inc., Milwaukee 4, answer the demand for a heavy-coated rod of definite physical qualities with easy deposition. Operating on reverse (positive) polarity, direct current, the electrode can be used in flat, vertical and overhead positions. Spatter loss has been reduced, and the beads are smooth. This electrode, known as Phos-Trode, is recommended for high-speed welding of bronzes, brasses, copper, steel, cast and malleable iron in all positions. It can also be used to weld dissimilar metals, such as copper to steel, bronze to cast iron, etc.

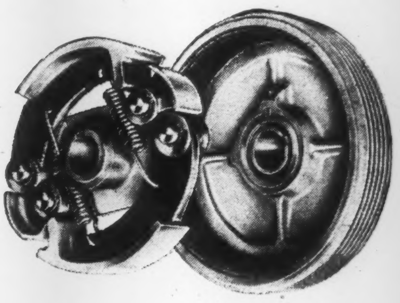
Umbrella Plugs for Rivets

UMBRELLA PLUGS of aluminum, copper or plastic, to match or harmonize with the material surface, have been made available by Cherry Rivet Co., 231 Winston St., Los Angeles 13, for use with its hollow-type rivets. For application in household appliances and industrial equipment, the umbrella plug fits into the center of the hollow rivet, and furnishes a smooth cap covering the rivet head. Shank of plug is knurled and tapered and fits tightly. These plugs may be used in rivets of 1/8, 5/32, 3/16 and 1/4-inch diameters.



Smooth-Running Automatic Clutch

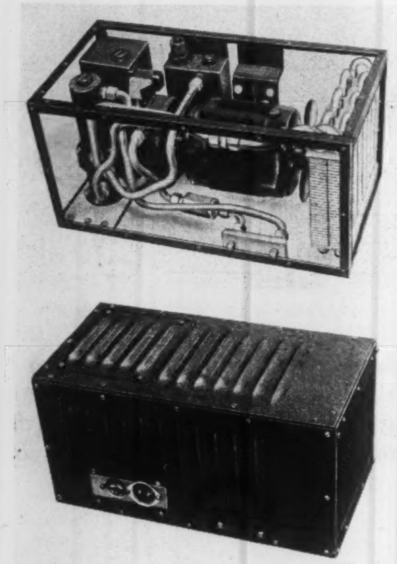
AN AUTOMATIC clutch to eliminate the shock of starting machinery or moving equipment has been developed by Salisbury Motors Inc., 4464 District Blvd., Los Angeles 11. For installation direct on the shaft of any engine or electric motor, the automatic clutch by centrifugal action progressively applies the power to the driven machine. Offering the advantages of a fluid drive, the clutch in addition permits complete disengagement while idling and positive engagement when driving. Of opposed shoe type, dual-spring balanced to give desired degree of tension, the clutch is available in two models: The 3-hp model has a drum diameter of 5¼ inches and length of



2 11/16 inches; the 6-hp model has a drum diameter of 7¼ inches and length of 4½ inches.

Heat Dissipating Unit

ORIGINALLY DESIGNED for ground, airborne and water services by Eastern Engineering Co., New Haven, Conn., a new heat dissipating unit is being offered for use in television, radar, short-wave radio communication, induction heating units, and many similar applications. The unit is furnished complete with thermostat control, thermostatic valves and flow switch. It will dissipate up to 1200 watts with a constant controlled temperature, irrespective of surrounding temperature, within a close heat control range of 2 C. Available in steel, bronze or aluminum, the unit measures 16 x 7½ x 7½ inches, and can be built to dissipate up to 5000 watts. Smaller models can also be built where required.

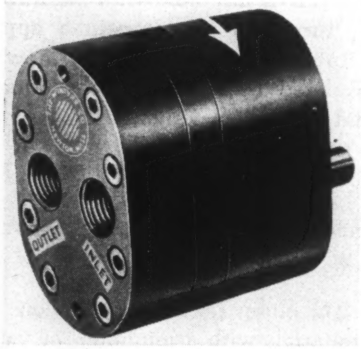


Carbon Brush for Motors

AMONG THE advantages offered in a new carbon brush developed by Speer Carbon Co., St. Marys, Pa., are an exceptionally wide band of commutation, high stability and long life. For use on many types of industrial electric motors and generators, this Grade No. 4029 brush can also be used for generators and traction motor units on diesel-electric locomotives. It is offered as a standard single piece brush or in the company's "Multiflex" construction.

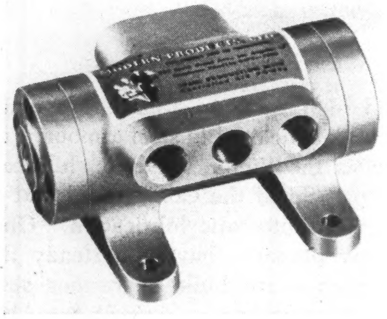
Spur Gear Pump

DELIVERING FROM ½ to 3 gpm at 1750 rpm, for continuous duty at pressures to 1000 psi, a new pump, Series 100, has been developed by The McIntyre Co., 15 Riverdale Ave., Newton 58, Mass. This compact and lightweight pump of rotary spur gear design has overall dimensions of 3¼ x 2¼ x 2¾ inches, with a weight of 1¾ pounds. All pumps in this series operate with a minimum volumetric efficiency of 90 per cent at 1000 psi and 1750 rpm when using oil of 100 SSU viscosity at 100 F. The pumps, of aluminum construction with nitrided nitralloy gears and shafts, are offered for direct motor, flexible coupled drive but can be supplied readily for all types of standard drives and a variety of mounting conditions. Power requirements vary between 0.40 and 2.25 hp for the various units at 1000 psi. By incorporating plastic housings and stainless steel gears and shafts, the pumps can handle water and other mild corrosives.



4-Way Control Valve

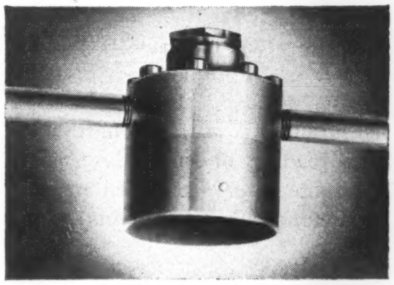
ADAPTABLE TO hand, foot or pilot operation, and known as Model CV Series, a new 4-way control valve has been introduced by Modern Products Ltd., 952 S. Grand Ave., Los Angeles 15. Designed for control of air and low-pressure hydraulic systems, the valves are adapted to the various operations by simple assembly changes of identical housings. The fully balanced valves use aircraft-type packing and are free of metal-to-metal contact between wearing parts, permitting transmission of full-line volume and pressure through the valve without affecting operation of valve. Design of the valve permits its use normally "on" or "off" in three positions, with the center position being "neutral". In "neutral" when valve is used for cylinder control, the unit may be arranged to permit positioning of the piston with pressure balanced on both sides of the piston, or with pressure relieved



at both piston ends. All of the adaptations can be used as single 3-way valves by plugging one outlet port or as two 3-way valves in series with one valve having the pressure on, while the other will have the pressure off. The valve is furnished with ⅜-18 NPT Female ports at 1-inch spacing on centers. It is also available in ¾-inch-18 port size, with other sizes contemplated for the future. Mounting pads are 4⅜ inches overall with 9/32-inch diameter holes on 2 13/16-inch centers. Width of valve body is 2 7/16 inches; overall height, 6¾ inches; and overall length, 7 5/16 inches.

Small Pressure Regulator

WEIGHING LESS than 2 pounds and measuring 2¾ x 3¼ inches, a new small and compact Mity-Mite regulator, announced by Grove Regulator Co., 6505 65th St., Oakland 8, Calif., is suitable for handling initial pressures up to 3500 pounds with adjustable control range from 5 to 1500 pounds. Special models can also be supplied for pressures ranging up to a maximum of 5000 pounds. Primarily designed for air and gases, including hydrogen, nitrogen, oxygen, etc., the regulator can also be furnished for liquid service. It is available for ⅛ and ¼-inch pipe size.



Locking Fastener

KNOWN AS the Lockbolt, a new type of fastener announced by Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, consists of two precision parts. One is a pin which has a head of any desired type, locking grooves, a breakneck groove, and pull grooves which fit the jaws of the driving gun, and the other is a locking collar. After the pin is inserted, the collar is slipped on and the gun applied. Both hand-operated and pneumatic guns can be furnished. As the gun pulls the pin, the reaction is taken by the collar against a swaging anvil in the nose of the gun, thus drawing the work together tightly. The pull on the pin is increased until the anvil is forced over the collar, squeezing the collar into the locking grooves of the pin to form a rigid, permanent lock. Pin is then automatically broken off at the breakneck groove, after which an ejector member in the gun advances to push the anvil off the collar, completing the operation. Lockbolts are now being furnished in 3/16-inch diameters with grip lengths ranging from 1/32 to 21/32-inch, and diameters of ¼-inch and 5/16-inch soon will be available. Materials include carbon steel, high-strength alloy steel, and 24ST aluminum alloy.

Incandescent Lamps

INCANDESCENT LAMPS specially designed for marine, power plant and industrial equipment service are now being furnished by Sylvania Electric Products Inc., 500 Fifth Ave., New York. For use where there is constant jar and vibration from heavy or high-speed machinery, the lamps are rated at 50 and 100 watts. Vibration resisting filaments for vertical lamp burning are designed to give 1000 hour life. Clear and inside frosted types are packed in standard packages of 120 lamps for 115, 120 and 125 volt service.

Engineering Dept. Equipment

Light Source for Photography

TO ITS LINE of stroboscopic equipment, General Radio Co., Cambridge 39, Mass., has added its Microflash, a light source for photographic exposures of the order of 2 microseconds. It consists of a power supply, which charges a condenser to a high voltage, and means for discharging the condenser through a special gas-filled lamp, producing an intense, short flash. This flash may be tripped by a make or break contact, an electrical impluse, or by a microphone which picks up a sound impluse from the phenomenon to be photographed. The microphone is supplied, separately and an amplifier and gain control are built in. Ordinary film and camera equipment may be used with the unit. Lamp and power supply are mounted in separate metal cases which lock together in a single unit. Dimensions (assembled) are 24⅛ x 13¼ x 11¾ inches, overall. Weight is 72 pounds.

Refillable Pencil

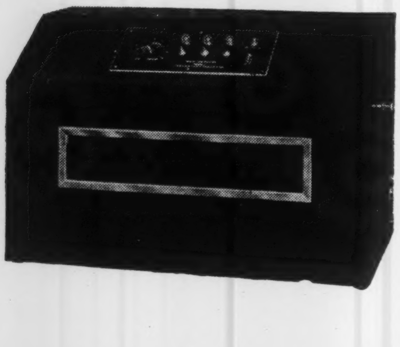
DESIGNED TO eliminate lead breakage, a new draftsman's pencil of Charles Bruning Co. Inc., 4654-8 Montrose Ave., Chicago 41, is refillable. This new No.3583 pencil is constructed on a new principle, having a clutch which holds lead firmly in a nonslip rubber grip, preventing nicking and scoring of lead. Especially designed for engineers and draftsmen, the pencil is light in weight and properly balanced. Having a long barrel, any full length standard drafting lead, from 0.079 to 0.070-inch (which includes HB and 9H) may be used. The grip is knurled to provide a firm hold.

Fluorescent Lamps

BRIGHTER YET more mellow light, instant illumination and double lamp life are features combined in a new fluorescent lamp offered under the tradename Safreen by Duro Test Corp., North Bergen, N. J. When not illuminated, the new light does not appear different from other fluorescent lamps but, when on, gives off a bright, safreen glow. Long life is achieved by the utilization of a heavy-duty cathode which increases lamp life, according to tests, to approximately 5000 hours. Another advantage of the light is that it provides instant illumination with the flick of the switch.

Printer Eliminates Darkroom

BY INCORPORATING an unusal light source—green fluorescent tubes—the new photo-arc printer of Peerless Photo Products Inc., 50 Broadway, New York, eliminates the use of a darkroom. Duplicate photo copies of drawings and manuscripts may be made in a normally lighted room, utilizing sensitized paper, transparent vellum or cloth which is photographically sensitive to green light but tolerant to ordinary electric light. The new printer also employs a new mechanical method of rotary printing which maintains unusual contact between original and copy, providing improved definition and sharp detail. Variation of light intensity for different types of work is provided by a rheostat control on the front panel, and the choice of one, two or three tubes. The printer operates at a fixed speed of six feet per minute.



Layout Protractors

LAYOUT PROTRACTORS, introduced by Engineers Specialties Division, The Universal Engraving & Colorplate Co. Inc., 980 Ellicott St., Buffalo 8, N. Y., were developed especially for requirements demanding accurate layouts for use on optical projectors and form grinders. Like the layout scale, of which it is a matching complement, the ruling is on the under side of the quarter-inch, beveled plate glass. Ruled lines of the protractor are in contact with the layout being produced or checked. Exactness of measurement on inspection screens of optical comparators is also assured. Beveled to a thin outer edge through which divisions are viewed, the circular edge of the glass contributes to the ease of marking measurements with a hard sharp pencil or scriber, or the reading of fine rulings closely spaced so that they designate intervals of ten minutes of arc. The protractor is divided into increments of ten minutes.

All-Steel Welded Drawing Board

HAVING AN ALL-STEEL frame, the new drawing board of Binkins Tool & Mfg. Co., 1513 Springwells Ave., Detroit 9, is made of welded tubular steel and reinforced with angle pieces. This construction holds the board true throughout varying weather conditions. Being light in weight, the board is easily adjustable to a tilt-angle of 60 degrees and an up-and-down movement of 6 inches. Equipped with rubber feet, it may be moved easily and quietly. Optional equipment is also available. This includes a reference tray shelf, and a light bracket assembly for 48-inch fluorescent lamps.

There is one RIGHT TIME

to select the BEARINGS

● The world is waiting anxiously for the new products of American genius. Much has been written about the new materials . . . new methods of manufacturing . . . new finishes that are now available. Never before has the designer had such a golden opportunity to break with the past and to strike out for the future. If the new product contains a motive unit, great care should be exercised in selecting the CORRECT bearings. The RIGHT time to decide what bearing will deliver the greatest performance . . . for the longest time . . . at the lowest cost is *before* production has started. The easiest way to determine this is to call in a Johnson Bronze Engineer. Permit him to review the application . . . to make a recommendation based on facts . . . free from prejudice. Remember, only Johnson Bronze makes EVERY TYPE of Sleeve Bearing. We are ready to serve you NOW!

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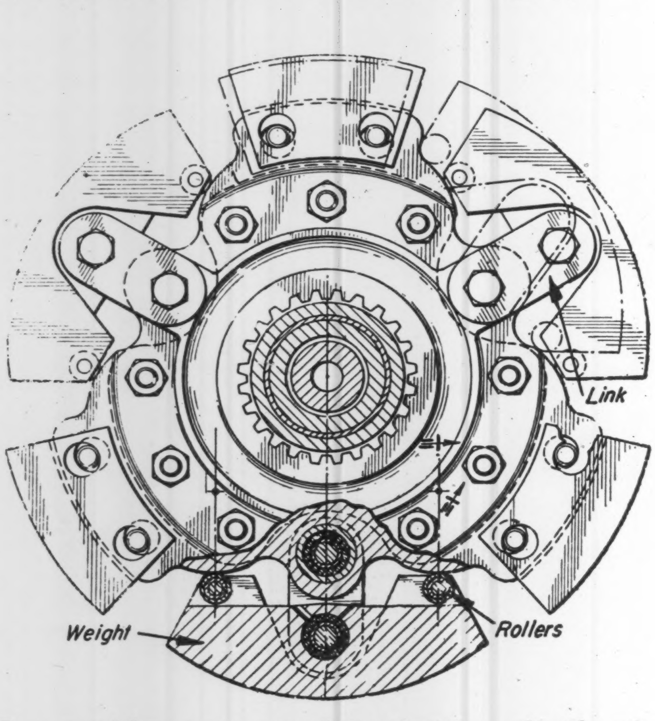
Noteworthy Patents

Damps Low-Frequency Vibrations

TORSIONAL dampers of the centrifugal pendulum type for use on internal-combustion engines present special difficulties where the number of twisting impulses during each crankshaft revolution is low. Ordinarily such a unit designed for a small number of swings must be comparatively long with respect to the distance from the center of the shaft to its fulcrum. An improved design obviating these difficulties and adapted to neutralize twisting impulses as low as one and one-half times per revolution is covered by patent 2,359,180 assigned to General Motors Corp.



Pure pendulum motion is obtained with a short-length weight swinging on a link and guided by rollers on a track

Shown in the accompanying illustration is a dynamic balancer utilizing this principle. Spaced 120 degrees apart are three conventional pendulum dampers supported by pins. Between these are located the improved dampers consisting essentially of a weight pivoted on a link and provided with guiding tracks and antifriction rollers. In swinging, all points on the weight move along arcs of the same length and radius maintaining pure pendulum motion.

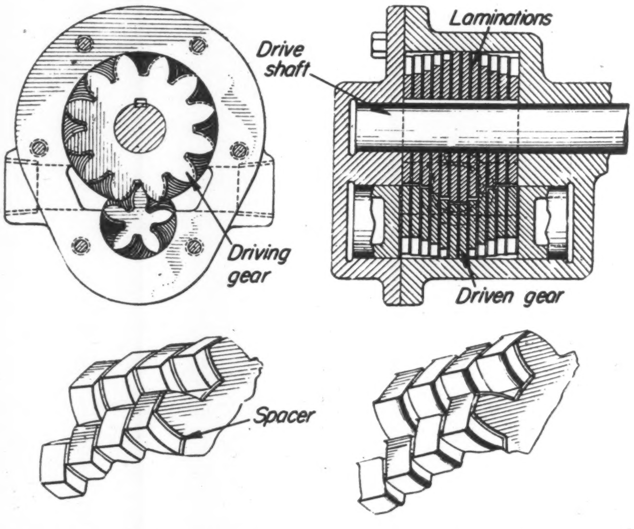
During operation of the engine to which it is attached, when subjected to uniform impulses matching the natural rate of swing of the weight, the weight oscillates back and forth on the link. Lag in the swing of the weight behind the torsional impulses tends to twist the engine crankshaft in the opposite direction and neutralize the effects of these impulses on the shaft.

Dynamically and statically-balanced arrangements as shown, or a single unit in place of the usual engine counterweight can be used. Multiple dampers are spaced according to the engine. A six-cylinder in-line engine employs 120-degree spacings as shown and that for an eight-cylinder in-line engine would be 90 degrees.

Pump Gears From Stampings

WITH a primary objective of reducing the cost of the gear units for gear pumps, recently assigned to Equi-Flow Inc. patent 2,362,106 covers the utilization of stampings for building up helical type gear units. Mass-produced precision stampings thus obviate the conventional methods for cutting gear teeth which of necessity consume considerably more production time. Stamped laminations are held in close contact by either hydraulic pressure of the pump itself or by bonding the laminations into a solid unit.

As shown in the accompanying illustration, helical type gear units are easily obtained without the disadvantage of axial thrust or the cost of double helical gears. To achieve this effect, successive laminations are stepped or displaced slightly, to form an approximate helical gear. Laminations, each being a thin spur gear, create no axial thrust and the slight angular displacement also eliminates trapping of hydraulic fluid between the teeth. Hydraulic shock, often a problem in gear type pumps, is thus effectively obviated.



Precision stampings, bonded into a single unit by means of brazing, produce efficient, low-cost helical type pump gears

An outstanding advantage is the practicability of pro-

it's *the metal of motion*

in winter sports, too!

And now . . . SKIS of magnesium!

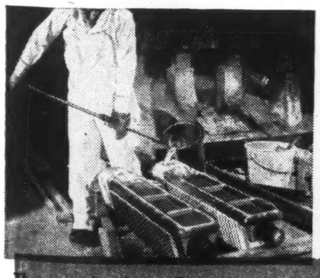
Here's a magnesium application—added to its successes in aircraft, portable tools, machine parts, and many other fields—that gives you a stimulating new picture of the versatility of this lightest structural metal.

These exceptional skis are made from extruded stock, milled to taper the ends, and with the tips formed hot. Designed and built by the American Ski Company, they have been intensively tested in use. Skiing experts report them faster and lighter than wood, and they require no waxing.

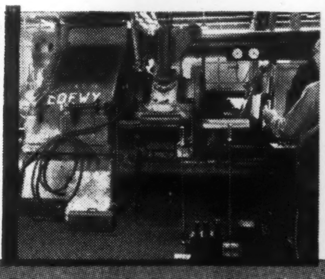
Dow research is constantly opening the way to new and important magnesium products and uses. For further information, simply contact the nearest Dow office.

Ready... to make products move! MAGNESIUM

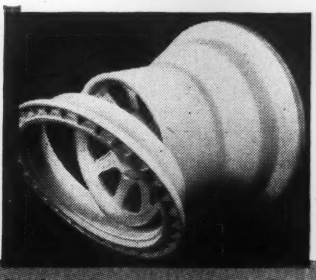
LIGHTEST OF ALL STRUCTURAL METALS



The production of magnesium metal by Dow is ample to supply the growing requirements of America's product manufacturers.



Fabrication plants throughout the country receive cooperation from Dow, foremost magnesium producer and leading fabricator.



Sand castings are among the many forms of magnesium in common use today in consumer and industrial products.

DOW

DOWMETAL

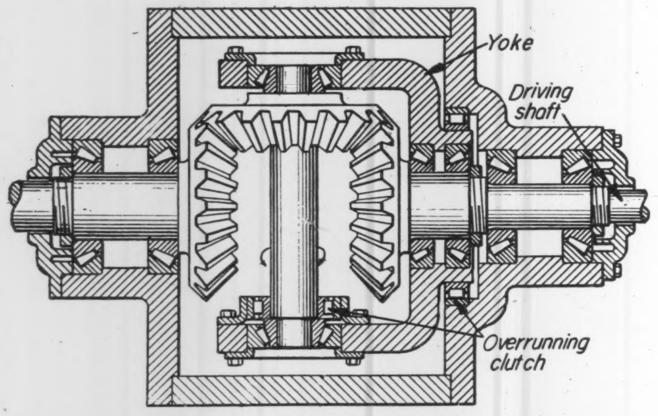
MAGNESIUM DIVISION • THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington • Cleveland • Detroit • Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle ducing almost any reasonable width of gear face desired without a change in diameter. Spacers of a thickness just sufficient to allow free rotation of the meshing teeth are employed to provide the bond. For a copper brazing bond, use of copper spacers 0.003-inch in thickness result in a final clearance between laminations of 0.002-inch at a maximum.

Similarly bonded spur gear stampings properly stepped in relation to each other can be utilized for both internal as well as external gear type pumps or motors. Flow can be conventional or axial. Where extreme accuracy is required, as with high-pressure or air pumps, a shaving operation is used.

Unidirectional Drive

TOTALLY enclosed and with the gears in constant mesh, the drive mechanism shown in the accompanying figure provides unidirectional rotation of the driven shaft regardless of the direction of rotation of the driving shaft. Assigned to the Westinghouse Corp. under patent 2,384,996, the drive design is primarily intended for operation of railway car lighting and air-conditioning generators normally driven by car axles.



Overrunning clutches controlling the action of a yoke and bevel gear provide unidirectional rotation at the driven shaft regardless of the rotation of the driver

For counterclockwise rotation of the driving shaft, the overrunning clutch of the yoke locks the yoke to the housing. Overrunning clutch of the yoke-gear shaft, however, is free to turn as shown by the arrow, bringing the bevel gears into action and producing clockwise rotation of the driven shaft.

Clockwise rotation of the driving shaft, however, locks the clutch on the yoke gear shaft. This produces free rotation of the yoke causing the three bevel gears and the yoke to rotate as a unit thereby creating again clockwise rotation at the driven shaft.

Driving and driven gears being of the same diameter, bearing speeds are no greater than those of the driving or driven shaft to assure satisfactory service life.

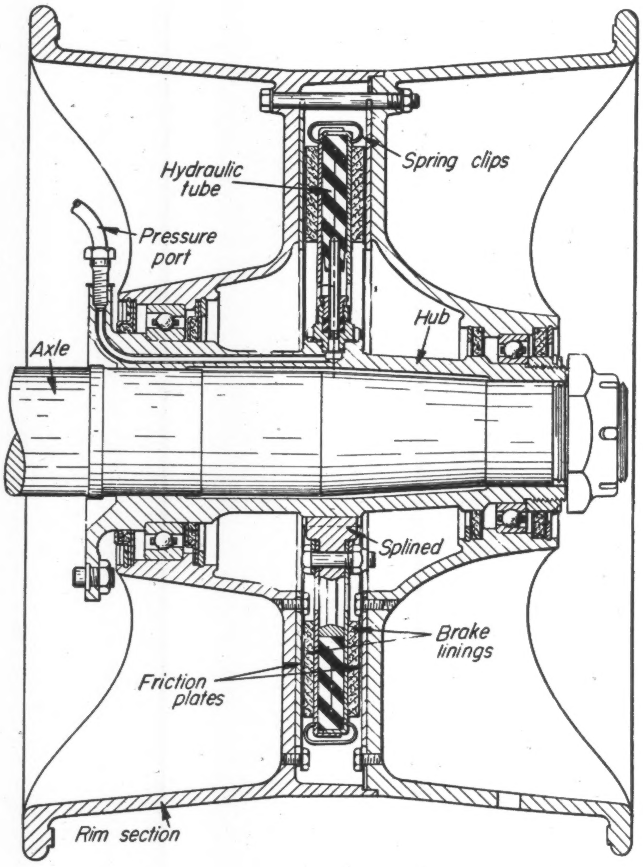
Similar results can be obtained by means of spur gears utilized for the drive in lieu of bevel gears if desired. The yoke for a spur gear unit, however, can be designed for either gear or roller chain and sprocket drive. Overall design of the bevel gear mechanism shown is more compact and balanced than that possible with a spur gear arrangement.

Hydraulic Disk Brake

TOTALLY enclosed within a special wheel structure, a new type hydraulically operated disk braking mechanism simplifies design and reduces weight. Adapted primarily to use with aircraft, the structure illustrated herewith provides many possibilities for the braking of any type vehicle wheels.

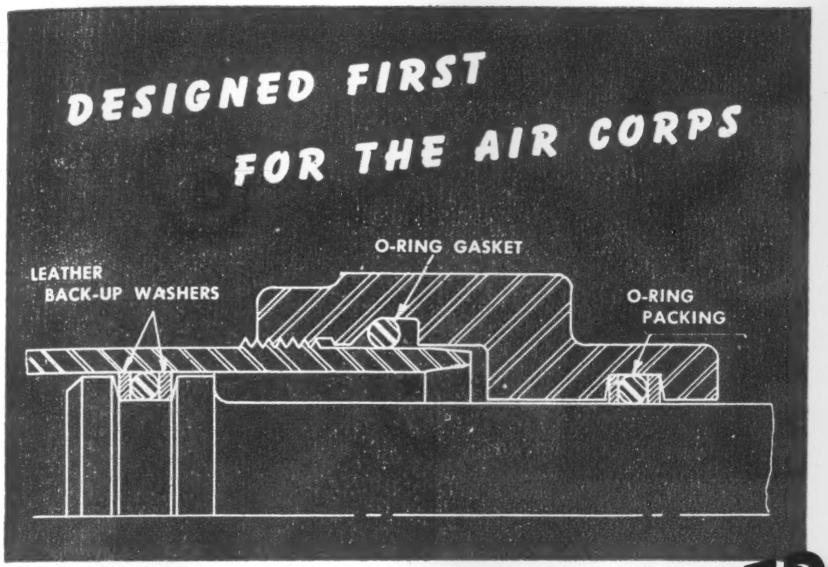
Covered by patent 2,381,166 assigned to Hayes Industries, Inc., the unit utilizes a multisection wheel body with special friction plates designed to restrict expansion strains. Both wheel bearings and brake mechanism are completely sealed from exposure or entry of foreign matter.

Hydraulic fluid entering a pressure port located on the stationary hub passes up through a special stem piece and into an annular hydraulic tube. Expansion of the tube forces the brake linings outward into frictional engagement with the pair of friction plates. Floating on a splined connection with the hub member, the braking unit is self-aligning and compensates for variations between the various parts.



Friction plates of cast iron used within a wheel body of lightweight alloy help to restrict expansion stresses

On release of hydraulic pressure within the unit, a series of spaced spring clips serve to collapse the tube and withdraw the linings from contact.



Typical gland design for "O" Rings and Vim Leather Back-up Washers. Complete specifications on design of standard grooves and tolerances will be furnished on request.

NOW BEING DEMANDED BY INDUSTRY

"O" rings and leather washers ... both supplied by Houghton

There's an obvious advantage in buying O rings and leather back-up washers from one source. That's why we emphasize that Houghton now supplies O rings in addition to our long-established line of leather packings and washers.

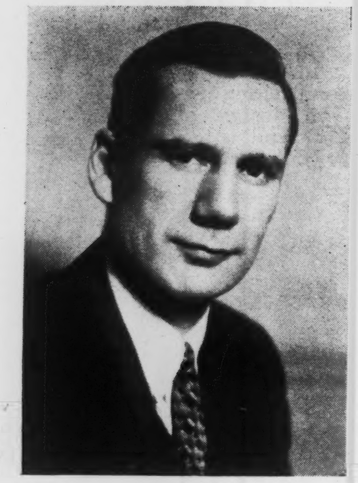
We are licensed under U. S. Patent 2,180,795 to supply O rings to manufacturers and users of hydraulic and pneumatic equipment, without making them liable to patent infringement.

Also we are supplying a complete line of homogeneous and fabricated packings, supplementing our well known VIM Leather line. Whether you require a Government (minus 65° F.) type of treatment, or the Commercial (minus 40° F.) type, which actually has more stamina—Houghton can furnish it.

Thus we have both feet in the packing business . . . can supply *all* your needs promptly, and help you with proper engineering design. That's worth remembering! E. F. HOUGHTON & CO., 303 W. Lehigh Ave., Philadelphia 33, Pa. Sales and service in all principal cities.

HOUGHTON'S

VIM Leather and VIX-SYN Packings



W. M. Walworth

David B. Smith

R. H. McCarroll

MEN... of machines

W. M. WALWORTH has been elected vice president and chief engineer of the Mack Mfg. Corp. Mr. Walworth has been acting chief engineer since March, 1945. He joined the Mack organization in 1939, after twelve years in the engineering department of Reo Motors Inc., Lansing, Mich. He began upon his automotive career immediately after graduation from Massachusetts Institute of Technology in 1926. Assigned first to Mack's Allentown, Pa., plant, he was soon moved to the New Brunswick, N. J., plant where he remained as chief engineer of the Mack Mfg. Corp. in March. He will continue to be in the company's general offices in the Empire State building, New York city.

DAVID B. SMITH who has been appointed vice president in charge of engineering of Philco Corp. is well known in the radio, radar and television fields. After receiving his electrical engineering degree from the Massachusetts Institute of Technology in 1933, Mr. Smith joined Philco the following year. He served first as a patent engineer on radio, television and other applications of electronics, and later was placed in charge of a special advanced studies group in the company's research and engineering department. In 1938 he was appointed technical consultant to the vice president in charge of engineering, and three years later was promoted to director of research. In this latter capacity he directed fundamental microwave and ultrahigh frequency research, leading to the production of many types of airborne radar used by the Army and Navy. He has also taken an active part in the development of television and in the establishment of national television standards. His society activities include a membership to the television committee of the Radio Manufacturers Association, and chairmanship of panel 9 of the national television systems committee in 1940. When the Radio Technical Planning Board was organized he served as chairman of the board's television panel which formulated and presented a detailed postwar program for the television industry to the Federal Communications Commission. In 1945 he was named chairman of the new television systems committee of the Radio Manufacturers Association.

RUSSELL HUDSON McCARROLL, executive engineer of Ford Motor Co., is the new head of all metallurgical, chemical and research activitives of the company. A graduate of the University of

REDUCE DEAD-WEIGHT—
INCREASE PAY LOAD WITH
J&L OTISCOLOY
HIGH TENSILE STEEL SHEETS

Otiscoloy high tensile steel sheets offer the design engineer new opportunities to eliminate bulk and dead-weight in new products. With 50,000 P.S.I. minimum yield point, 70,000 P.S.I. minimum tensile strength, 25% elongation in two inches, Otiscoloy is ideally suited for many applications. Otiscoloy resists corrosion, abrasion and has excellent weldability. It forms hot or cold. J&L Otiscoloy is now available in sheets, strips, plates, Jal-Tread floor plate, Junior Beams, Junior Channels, Electricweld tubing and hot and cold finished bars.

JONES & LAUGHLIN STEEL CORPORATION
PITTSBURGH, PA.

Michigan, Mr. McCarroll joined the Ford organization in 1915. He holds a long list of patents, chiefly in the field of metallurgy. He directed the development of the centrifugal casting method used to advantage by Ford in the mass production of aircraft engines. To his credit also is the development of cast steel crankshafts, valves, push rods and other parts used in the automobiles. On the chemical side he is responsible for a process used in the manufacture of an improved type of artificial leather. Mr. McCarroll has also devised a system of coke oven fuel handling and has been active in the company's soy bean experiments which led to the production of synthetic lacquer from soy beans.

◆

Brig. Gen. Tom C. Rives has returned to Wright Field after an absence of nine years, to act as chief of the radio and radar subdivision of the engineering division.

◆

Robert F. Nelson in his appointment as vice president and assistant to the president of R. G. Le Tourneau Inc., brings to his position an extensive background of engineering, production and administrative experience.

◆

Dr. Francis C. Frary, director of research of Aluminum Company of America, has been elected to receive the Perkin Medal awarded by the American Section of the Society of Chemical Industry in recognition of his outstanding accomplishments in the field of industrial research.

◆

N. F. Adamson has been elected vice president in charge of engineering and sales of the Twin Disc Clutch Co. Mr. Adamson, who most recently had been general sales manager, had been chief engineer for many years, and prior to that time worked with the sales and engineering departments. **G. W. Buelke** has been appointed chief engineer of the Racine division.

◆

H. J. French has resumed his duties as assistant manager of the development and research division of The International Nickel Co. He resigned as assistant director for raw materials and facilities of the steel division, War Production Board.

◆

Raymond H. Gaver will head the Railway Equipment Division of the American Welding & Mfg Co., Warren, O., as chief engineer, while **Jonas D. Bigelow** will act as development engineer. Mr. Gaver has been with the company since 1944 working at research and development on new car and locomotive components.

◆

Peter V. Armstrong, well known industrial designer, has become chief of the Federal Machine & Welder Company's new consumer goods division.

◆

Harry A. Winne, who for some time has been vice president in charge of engineering for the General Electric Company's apparatus department, has been appointed vice president in charge of engineering policy for the entire company. **Ernest E. Johnson**, assistant engineer of the aeronautics and marine engineering division, will succeed Mr. Winne.

◆

C. J. Smith as the new chief engineer of the Monroe Auto Equipment Co., will direct the organization's expanded program in the transportation field. Mr. Smith previously had been with the Packard Motor Car Co. where during the war, he was in charge of the experimental engineering program at the tank arsenal proving grounds, Utica, Mich.

◆

Clark M. Humphreys, who has an extensive background in heating and ventilating design, has joined the research laboratory of the American Society of Heating and Ventilating Engineers, as senior engineer.

◆

Ralph A. Powers has been appointed engineer-in-charge of electronic engineering for Allis-Chalmers Mfg. Co. Formerly connected with Bundy Tubing Co., Mr. Powers holds numerous patents on electronic devices and has prepared many technical papers on this subject.

◆

James Creese, vice president of the Stevens Institute of Technology since 1928, has been elected president of Drexel Institute.

◆

John A. Allwood, Jr., executive vice president and general manager of Lear Inc., has been named a member of the board of directors. Mr. Allwood has had more than twenty years experience in engineering and gearing problems.

◆

Ernest G. Whitney has been appointed assistant chief engineer, Ranger Aircraft Engines Division, Fairchild Engine & Airplane Corp.

◆

A. C. Montieth has been made assistant manager of Headquarters Engineering, Westinghouse Electric Corp. Manager of the Industry Engineering Department since 1941, Mr. Montieth will direct headquarters engineering activities in the absence of **C. A. Powel**, assigned to the military government of Germany.

◆

Harold Minges, former design engineer with Busch-Sulzer Bros. Diesel Engine Co., is now layout engineer with Baldwin Locomotive Works, Philadelphia.

◆

Dr. Earl Flosdorf has been appointed director of research and development, F. J. Stokes Machine Co. He had been a member of the faculty at the University of Pennsylvania for fourteen years.

◆

E. I. Pollard has joined the engineering staff of the Ridgway plant of Elliott Co., Jeannette, Pa. Formerly Mr. Pollard had been with Westinghouse where he was in charge of the design of alternating-current marine generators.

◆

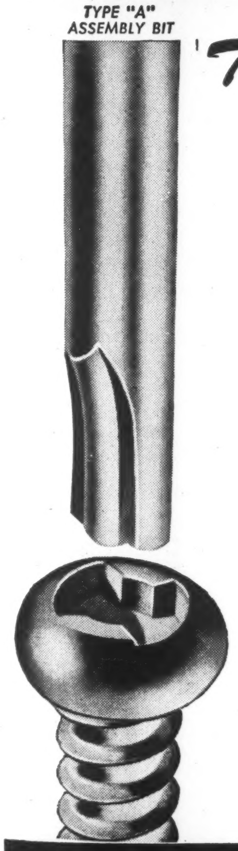
E. J. Schwanhausser, vice president of Worthington Pump & Machinery Corp., was elected president of Diesel Engine Manufacturers Association.

◆

Gerard Swope of General Electric Co. was awarded the ASM Medal for Advancement of Research in recognition of his pre-eminent share in many of the important developments in metallurgy in recent years. Among others to

Quam Reports:

"20% STEP-UP, SLIPPAGE ELIMINATED AND SERVICE PROBLEMS SIMPLIFIED"



The Clutch Head Pay-Off in Performance

and lower cost is definite. Using this exclusive Lock-On feature for precision assembly of their "Adjust-A-Cone" Units, QUAM-NICHOLS CO., CHICAGO, record a 20% increase in assembly operation as well as the solution of two important problems. Damage from driver slippage went to zero and the simplicity of common screwdriver operation disposed of field service handicaps.

THIS LOCK-ON, available only with CLUTCH HEAD, is effected with a simple reverse turn of the Type "A" Bit in the head recess. This unites screw and bit as a unit for speedy, easy one-handed reaching to hard-to-get-at spots.

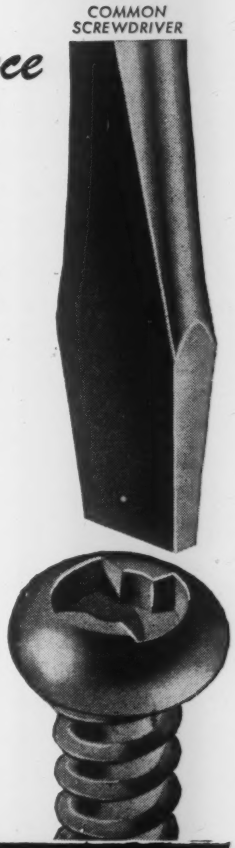
IN "UN-BUTTONING" THE JOB TOO, the reverse action automatically forms the Lock-On. Thus the Type "A" Hand Driver for field service withdraws the screw undamaged and safely held against dropping or loss for re-use. In many cases, this automatic Lock-On saves the dis-assembling of surrounding units.

You may personally test this feature, and the many other exclusive CLUTCH HEAD advantages for faster, safer, smoother, and lower cost production. Ask us to mail you package assortment of CLUTCH HEAD Screws, sample Type "A" Bit, and illustrated Brochure.

This rugged Type "A" Bit is important to tool economy. It delivers longer uninterrupted service and its original efficiency may be repeatedly restored by a 60-second application of the end surface to a grinding wheel.

CLUTCH HEAD SCREWS

Check the perfect operation of this screw with an ordinary type screwdriver or any flat blade, reasonably accurate in width. This is an exclusive feature that contributes importantly to emergency service in the field.



UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7

receive recognition by the Society are: **Earle C. Smith**, chief metallurgist, Republic Steel Corp., who has received the Gold medal; **Robert S. Archer**, metallurgical assistant to the vice president, Climax Molybdenum Co., the 1945 Sauveaur Achievement Award; and **Dara P. Antia**, **Stewart G. Fletcher** and **Morris Cohen** of the department of metallurgy, Massachusetts Institute of Technology, the 1945 Howe Medal.

◆

Orrin Broberg has been made chief engineer of the marine equipment division of Ellinwood Industries. **John H. Williams** is the new project engineer with the farm equipment division of the company.

◆

Paul Peckar, previously assistant senior division engineer of the Reconstruction Finance Corp., has joined the engineering staff of Tenney Engineering Inc.

◆

Preston Robinson, associated with Sprague Electric Co. since 1929, serving most recently as chief engineer and director of research, has been named vice president of the company.

◆

Bingham H. Van Dyke, previously assistant to the director of research and development, Elliott Co., has been appointed manager of the new products department.

◆

Frank T. Christian, connected with the company's engineering staff since 1929, has been appointed chief engineer of the Eclipse Machine division of Bendix Aviation Corp. Since 1940 Mr. Christian directed engineering for the company's commercial production of Bendix starter drives and bicycle coaster brakes.

◆

Clinton R. Hanna, inventor of the gyroscopic tank gun stabilizer, was recently presented the degree of Doctor of Engineering by his alma mater, Purdue University.

◆

E. U. Lassen, who has been connected with Cutler-Hammer Inc. since 1924, has been appointed assistant chief engineer.

◆

William Wiseman, formerly chief engineer of Warner Aircraft Co., has joined the aircraft division of Continental Motors Corp. as assistant chief engineer.

◆

Lewis A. Rodert, previously section head of flight engineering, Ames Aeronautical laboratory of the National Advisory Committee for Aeronautics, Moffett Field, Calif., has joined the research staff of Stewart-Warner Corporation's heater plant at Indianapolis.

◆

Walter Ernst, director of engineering, The Commonwealth Engineering Co., has been advanced to vice president in charge of engineering for the company.

◆

Nathaniel Warshaw, well known as a consulting engineer in materials handling equipment, has been made head of the materials handling division of Market Forge Co.

◆

P. D. DeLeo, development engineer, has been added to the engineering staff of Progressive Welder Co. **I. A. Crawford** is the new research engineer, while **E. Y. Bunting** has been named machine design engineer.

◆

Orland H. Yoxsimer, as manager of the Westinghouse household refrigerator cabinet engineering division, will be responsible for the coordination and development work on domestic refrigerator cabinets at the East Springfield and Mansfield, O., plants.

Twin Ellipses in Pump

(*Concluded from Page* 142)

0.0001-inch. Plungers and cylinder bores are ground and lapped to reduce leakage to a minimum. Such leakage as does occur, however, is utilized to lubricate axles, rollers, and the joint betweeen the plunger and axle. Close examination of the inset in *Fig.* 3 will show a small slot milled in opposite sides of the plunger at its midsection. Drilled holes provide passages from these slots to the tongue which fits into a mating slot in the axle, and leakage can follow this path to lubricate the moving parts.

A small circulating pump is incorporated for the purpose of circulating oil under low pressure direct from the oil tank through the pump housing and then to the tank. This insures sufficiently low pump housing temperatures under the condition of extreme pressure operation at zero or near zero delivery, when heat conditions are most severe.

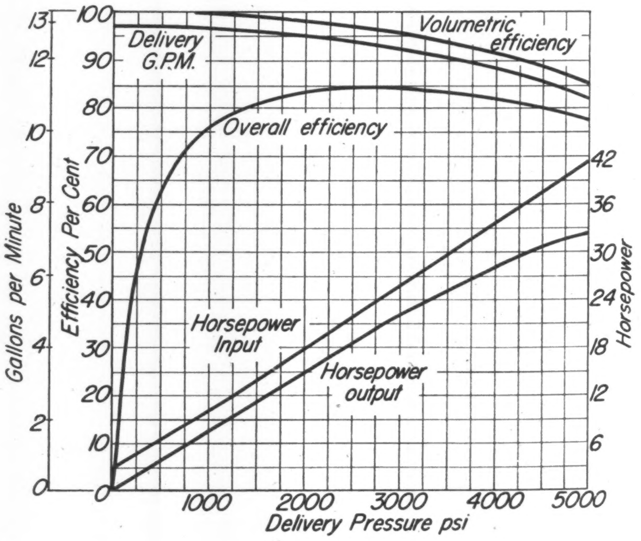
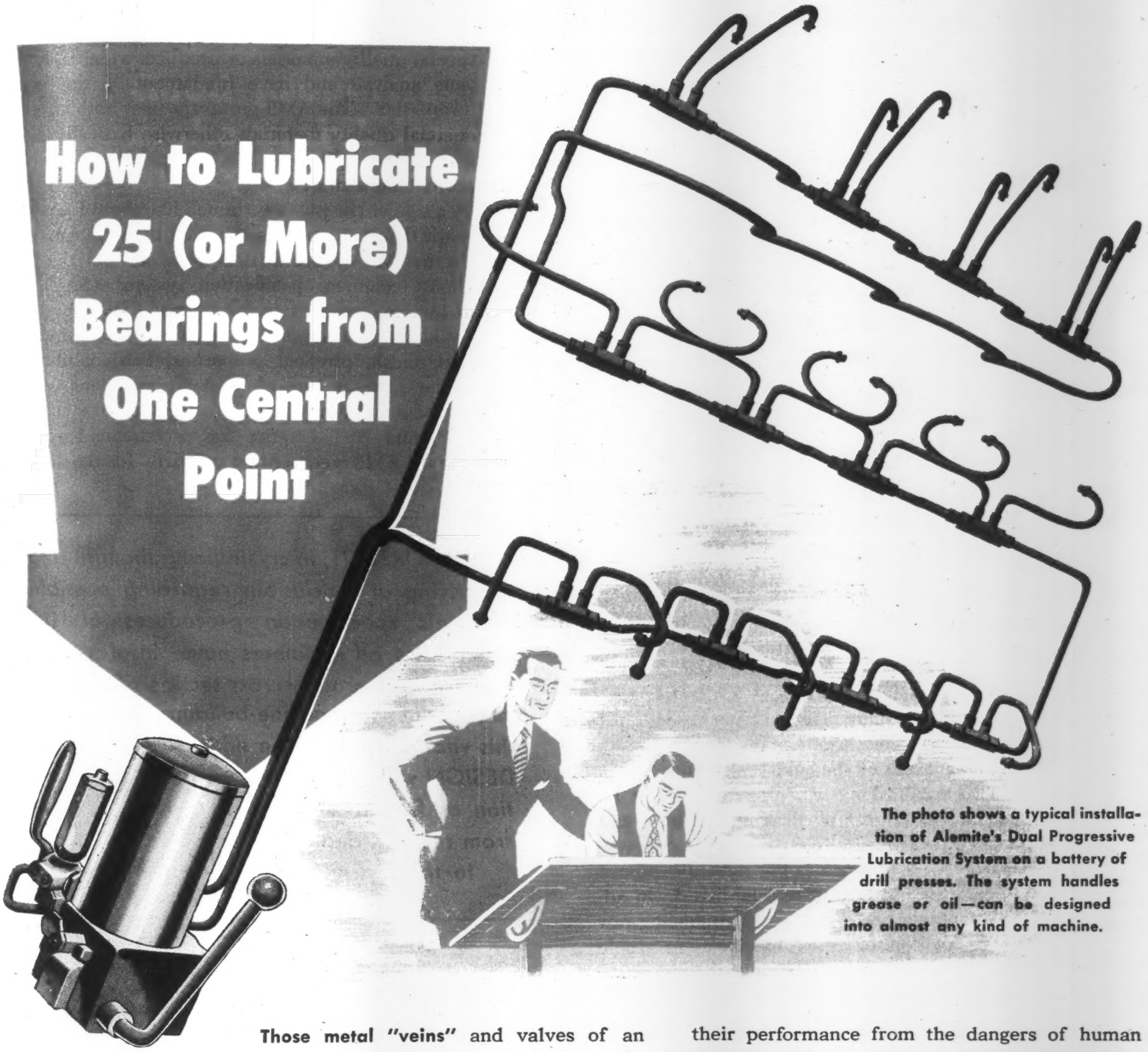


***Fig. 5**—Typical performance curves of double bank Superdraulic pump when driven at 1200 rpm*

Modification of the design to serve as a high-torque hydraulic motor consists in substituting for the elliptical rings reaction rings of other forms. Use of a three-lobe cam ring, for example, provides three plunger strokes per revolution and a top speed two-thirds that of the pump. It also provides torque multiplication.

Typical performance curves of a double-bank pump at 1200 rpm are shown in *Fig.* 5. The unit has an overall height of 11 inches, width 14¾ inches, and length 16 15/16 inches. By the use of light alloys to reduce weight, and by "supercharging" to permit high flow rate through the intake passages, speed and horsepower capacity can be greatly increased, making such units feasible for automotive drives.



How to Lubricate 25 (or More) Bearings from One Central Point

The photo shows a typical installation of Alemite's Dual Progressive Lubrication System on a battery of drill presses. The system handles grease or oil—can be designed into almost any kind of machine.

Those metal "veins" and valves of an Alemite System carry the "lubricant lifeblood" to every bearing surface on a machine. Think of it in terms of the machine—any machine—you're designing now.

No matter if your machine or a battery of them has 10, or 25, or 40, 60, or 75 lubrication points. The Alemite System reduces them all to *one*—the one central point where the lubricant is introduced. From there, each bearing receives a measured quantity of lubricant—*and without stopping the machines.*

Proof? For example: a battery of 7 big automatic punch presses has a total of 86 bearings. It took 20 minutes to lubricate each press—and it had to be shut down. Bearing failures were frequent. Now all 86 bearings are lubricated from one central point *while the presses are in operation.* Bearing failures due to faulty lubrication have ended.

When you design Alemite Centralized Lubrication into your machines you automatically protect their performance from the dangers of human error. You reduce the number of lubrication points to *one.* You guarantee positive lubrication without "time-outs." You cut repairs to a minimum . . . lengthen machine life . . . increase customer satisfaction. It all adds up to More Productive Time per machine. And that enhances your reputation as a designer.

* * *

Without obligation, have an Alemite Lubrication Specialist demonstrate one or all 4 new Centralized Systems right at your desk with transparent working models. Also, ask for any technical help you want regarding Alemite Systems. Drop a note on your letterhead to Alemite, 1804 Diversey Parkway, Chicago 14, Illinois.

ALEMITE

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ALEMITE HELPS THE WORLD GO ROUND

Another Product of STEWART WARNER

Alemite **ALONE** *Combines all 3 in Lubrication*

1. EQUIPMENT 2. PROCEDURES 3. LUBRICANTS

Specification Symposium

(*Continued from Page* 106)

tions, plus the previous AISI, SAE and ASTM specifications, tend to produce a condition that is difficult to co-ordinate. All are basically similar and vary only in a minor degree on some one item that is considered vital to that industry served by the specification. Prior to the war each industry knew only of the specifications for that industry and rarely realized how nearly alike the other standards were for the same product. Due to the war many industries have learned of these different specifications and have become confused as to the actual need for so many.

Establishment of a single materials specifications system, however, has many problems. Each industry requires various materials that may differ only slightly from those used by another industry. These differences are the main reason for the varied systems of today, and until they can be incorporated into one master system, or the industries re-educated to use the similar material, the problem is far from a quick solution.

The various technical societies, which naturally like to have specifications of their own for use in the industries with which they are allied, present another difficulty. These different societies must become closely co-ordinated in order to make a single specifications system work. Each society must contribute its share and no one group must control exclusively the specifications of a given material. This means the elimination of the selfish elements within each group and the establishing of a broader outlook by the societies for the betterment of all manufacturing and not alone for a small controlled group.

It would certainly be a big step in the right direction if one single materials specification were established. In addition to other advantages, mills and plants producing raw and finished materials controlled by specifications would welcome the clarification and simplification resulting.

. . . number of systems might be reduced

By R. D. Zonge
Chief Metallurgist
Lycoming Div., The Aviation Corp.
Williamsport, Pa.

A SINGLE material specification system would not be practicable even though it may be desirable. There is the hope, however, that the existing systems could be reduced in number to eliminate some of the confusion existing today.

The Federal Government and the Services must, of course, have procurement specifications since they are compelled to buy from the lowest bidder. Industry, on the other hand, would not be content to live with such a system or systems of specifications.

There is no need, however, for the duplication of specifications caused by each government agency having its own system. One or two systems common to all branches should suffice. The possible question of two systems is acknowledged because of the need for differentiation between commercial quality materials or products, and aircraft or special quality materials or products which may be of the same analysis and have fundamentally the same physical properties. The AMS group specifies both aircraft and commercial quality materials otherwise basically alike in the same system, although it is granted that these instances are not numerous.

Industry's side of the picture is much like that of government's except that it is more complicated by large quantity needs of somewhat special quality material, and the fact that the most common specification systems (SAE and AISI) are not procurement specifications. These systems are merely chemical composition limits with no reference to hardness, finish, physical properties, hardenability or quality. The same is true of most specifications of the materials producing companies.

The AMS and ASTM series are procurement specifications, but the AMS were written primarily for the aircraft industry and the majority of materials described are special quality, while the ASTM were prepared for other special industries and cover commercial quality materials.

It is possible that two agencies, such as these, could cover the industrial field, and eventually even combine into a single numerical system. Probably wider acceptance and use of the hardenability test as an additional means of specifying steel will help to reduce the number of specification systems now in use.

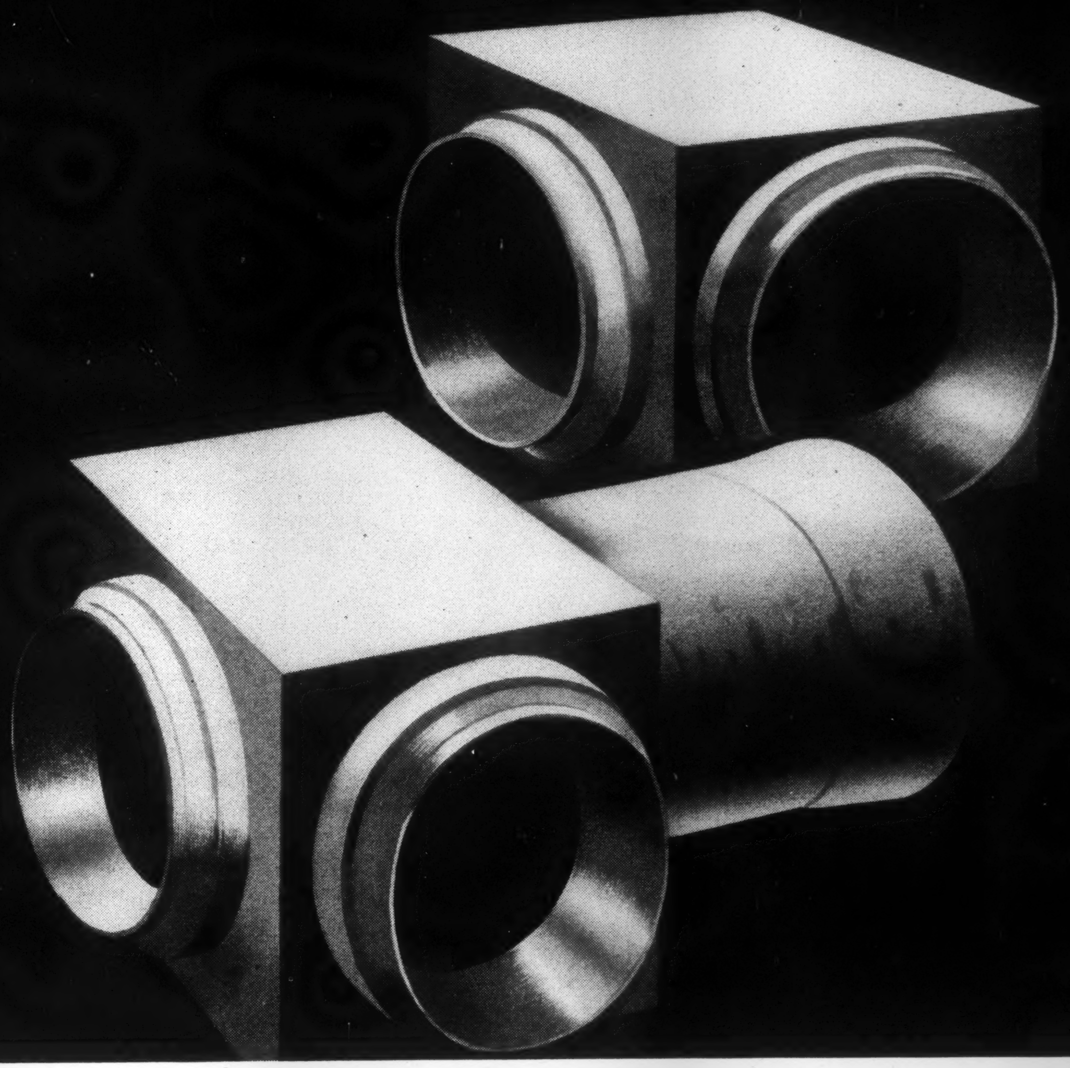
IT IS IMPORTANT, in crystallizing thought and in arriving at conclusions regarding possible materials specification procedures of the future, that all engineers have—insofar as is feasible—a thorough cross section of thinking throughout the machine-building industry on this vital question. The editors of MACHINE DESIGN will be glad to consider the publication of further pertinent comments received from readers dealing with factors additional to those discussed in this symposium

. . . would be a distinct advantage to all

By George N. Barrett Jr.
Chief Metallurgist
Cleveland Pneumatic Tool Co., Cleveland

ESTABLISHMENT of a single set of materials specifications would be a distinct advantage to all parties concerned. The steel industry, as an example, would have fewer specs to make and, therefore, there would be a much smaller number of missed or "off" heats. Steel of this type is a serious handicap and burden, causing disruption of schedules, broken shipping promises, and occasionally entailing considerable loss of money. This same

Good properties from mild quenching make molybdenum steels suitable for bulky, complicated parts.



MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"
CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

MOLY

Climax Molybdenum Company
500 Fifth Avenue · New York City

condition would prevail in other materials plants.

In respect to the users or fabricating plants, the confusion due to the multitudinous volumes of specs reached its peak during the war. It grew so great that some of the smaller shops were forced to expend money setting up specification departments to keep up to date on all specifications. Even the large industries, which normally write their own specs, were confronted with unfamiliar Army, Navy, and Air Corps Specs. No doubt the greatest confusion occurs in the purchasing departments where engineering and metallurgical requirements call for a type of material under a certain specification. When this is not obtainable, usually a substitute is offered in another specification system. The buyer then is confronted with the question: Is this the same type and quality of material as specified by his engineering department or is it in some way inferior? By the time he gets this question answered by an already busy or overworked engineering or metallurgical department, considerable time is lost and sometimes even the material—it being sold to another buyer.

The writer knows of a plant where 35 to 40 per cent of their rough material orders (steels, brasses, bronzes) had to be filled by substitutes. This was true even though SAE standards usually were specified. The majority of the above orders were for warehouse quantities which was a large factor in the number of substitutions that had to be made. It is the small manufacturer—the warehouse customer—whose costs must be held to a minimum in order to survive competition and reconversion, who suffers the greatest confusion and delay due to nonstandardized specifications.

Manufacturers, large and small, would certainly benefit greatly and a lot of their purchasing headaches would be eliminated if one set of materials specifications could be standardized for the nation. The writer cannot see why this would not be possible. Other countries have done it and, advanced in engineering as we are, we certainly are capable of doing it. Surely we need it more now than ever before.

. . . desirable . . but problem is extremely complex

By A. E. Gibson
President, The Wellman Engrg. Co.
Cleveland

IT WOULD be desirable for equipment builders such as we are, to have single materials specifications, but we do not believe that it woud be possible to get government agencies and industry to adopt them.

Take for instance the steel industry for which we build equipment. Practically every company has its own ideas on specifications and materials and they insist their equipment be built to them.

Yards and Docks division of the Navy have recently adopted a specification that all important steel castings such as trucks and equalizers be subject to x-ray examination. This is costly and time-consuming. Yards and Docks are willing to pay the price, but industry will not.

Some steel companies call for a factor of safety of 5 or 6. One, the largest, insists upon 10 on highly stressed equipment. Some companies insist all gears be hardened, others will take them of lower brinell.

I could cite hundreds of similar cases which make the problem so complex that I question ever arriving at one set of standards acceptable to everyone.

. . . societies should welcome chance for collaboration

By George Webb
Director, Research and Development
Colt's Patent Fire Arms Mfg. Co.
Hartford, Conn.

THERE are approximately 2000 specifications on steel alone and 1500 specifications on nonferrous metals. This summary is based on the cross index prepared by the General Motors corporation at the request of the United States Armed Services and revised March 1, 1945. During the war emergency there were a great many headaches caused by slight variations between one specification and another which resulted in many a delay in the production line, whereas the variation would not have affected the completed part.

Certainly the various agencies and societies which have a major part in the preparation of specifications would welcome an opportunity to determine whether the various codes and specifications now in use could be materially reduced. Were this reduction accomplished, it would surely be welcomed by both mill and manufacturer.

. . . need exists . . . will be difficult, require time

By J. Perina
Standards & Materials Engr.
Republic Aviation Corp., Farmingdale,
Long Island, N. Y.

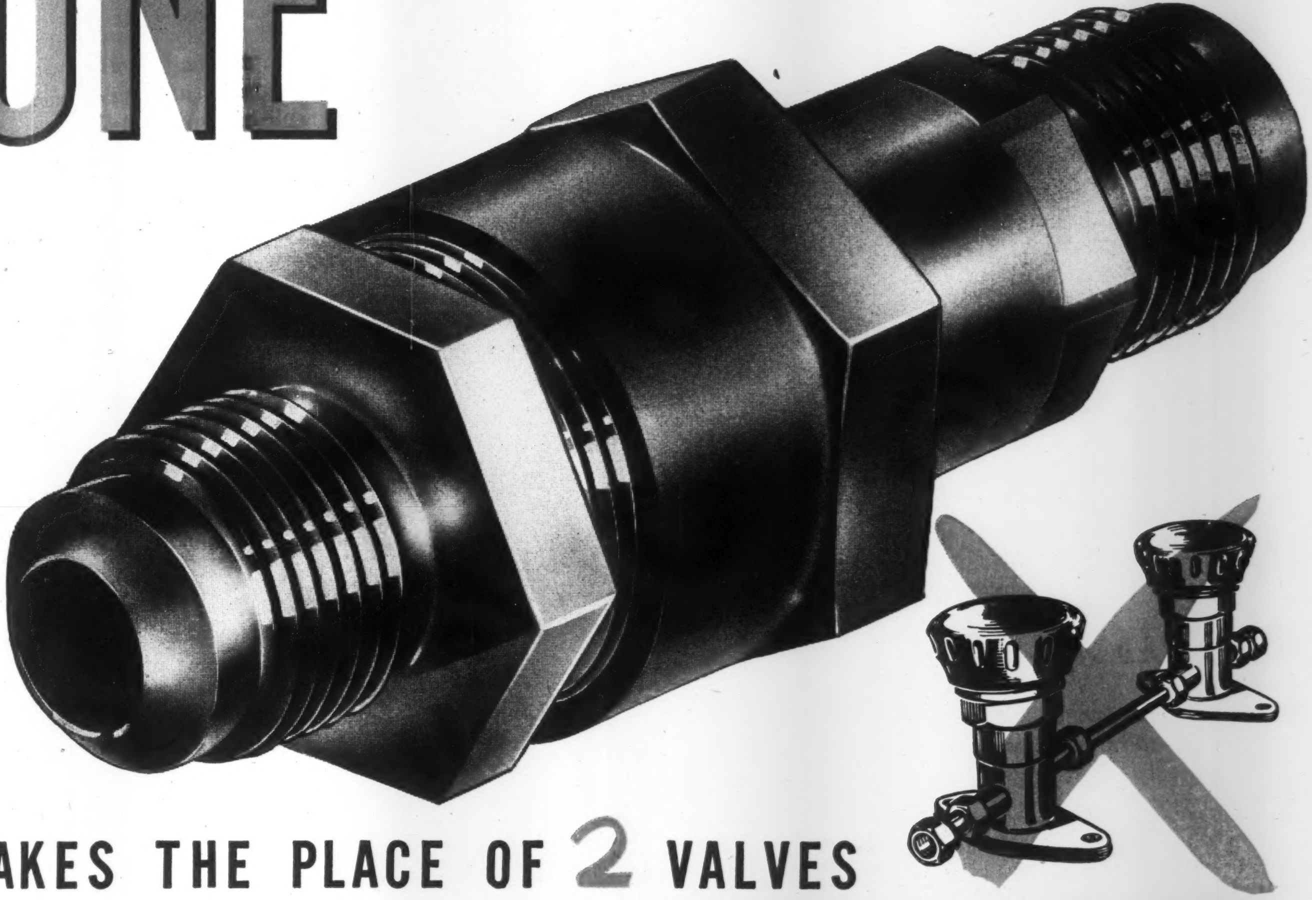
BASICALLY, the need for such a system exists and its acceptance would simplify the entire material manufacturing and procurement problem. But it is to be expected that no one set of existing specifications will completely satisfy all requirements. Special applications requiring special materials will continue to crop up. This is unavoidable and, in some cases, necessary if progress is to be made and competition is to flourish.

Establishing a standard set of specifications, like any other form of standard, will be difficult and will take a great deal of time. Opposition from fabricators may be encountered to a great extent. In many cases such opposition may be justified due to each designer's problems or manufacturer's fabricating technique, and a solution must be offered in each of these cases.

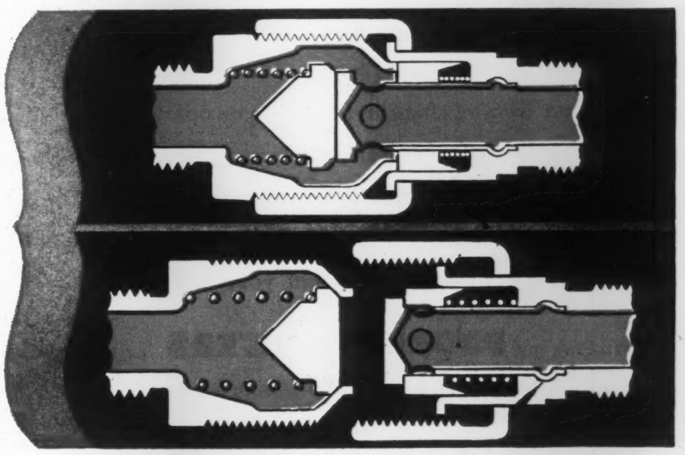
One way in which the establishment of a standard series may be accomplished is to select the most commonly used series and expand or modify the requirements to satisfy a majority of the users.

Another obstacle to overcome, however, is the selection of the society or organization to control, publish and designate the specifications. It is because one such organization was not designated that the present problem exists. It may be that the American Standards Association would be the most qualified and in the best position to handle this work.

ONE AEROQUIP SELF-SEALING COUPLING*



TAKES THE PLACE OF 2 VALVES



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DURANT MANUFACTURING COMPANY
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Design of Gears for Rail Drives

(*Continued from Page* 140)

volving different pressure angles and tooth proportions. The 14½-degree and 20-degree pressure-angle designs with standard proportions are well known, while the 20-degree and 25-degree long-and-short-addendum designs are growing in popularity.

Gearing of higher pressure angles operates at lower compressive stress for the same unit loading. The relative magnitudes of compressive stress at the pitch line on 14½-degree, 20-degree, and 25-degree pressure-angle gearing are 100 per cent, 87 per cent, and 79.5 per cent, respectively. Also the higher pressure-angle systems have teeth of superior strength in bending.

Since there is frequent use of pinions with as few as 15 teeth in railway-motor design, it is not desirable to use a design of gearing in which the pinion must be undercut. It has been found advantageous to use 20-degree pressure-angle long-and short-addendum gearing. The combination most often used is one in which the pinion addendum is approximately 35 per cent longer, and the addendum of the gear 35 per cent shorter, than the standard proportions of $1/DP$, where DP is the diametral pitch. When these addenda are used, the pinion tooth is made thicker than standard to balance the strength between the gear and the pinion.

Tooth Characteristics Compared

In *Fig.* 6 is shown a 20-degree pressure-angle tooth laid out to these proportions, together with some other tooth designs for comparison. Heavy lines on the tooth surfaces show the portions of the profiles on which full load is taken by one tooth, percentage figures represent comparative bending stresses for equal loading, and dots on the tooth surfaces marked "L" are the lowest points of contact. The 25-degree tooth has the same width of top land as the 20-degree long-addendum tooth. Both are proportioned so that the pinions and their mating gears may be cut with the same hob, which results in slightly less addendum on the 25-degree tooth design.

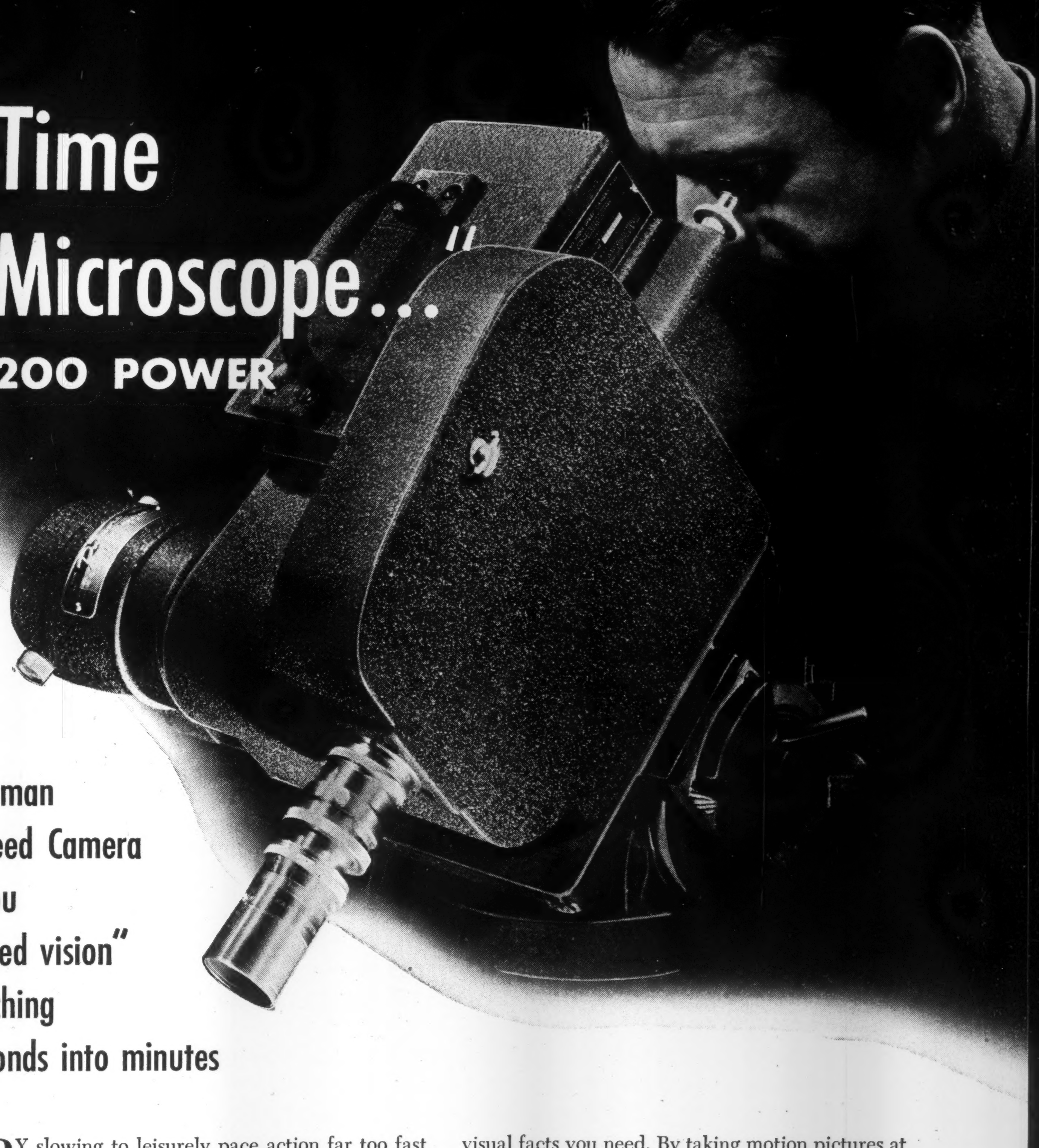
Principal advantages of the 20-degree and 25-degree long-addendum designs are as follows:

1. There is no undercutting of the tooth, even on a 15-tooth pinion
2. Greater tooth strength is provided
3. Root diameter is larger, permitting the use of a larger shaft for the same metal section between tooth root and bore, or a thicker metal section for the same shaft size. The 25-degree tooth has the disadvantage that the number of teeth in action is relatively low.

Design of the root-fillet radius was never given serious attention until it was discovered that the fatigue life in bending was greatly influenced by the stress concentration at the fillet. Development of the continuous-radius fillet began about 1930, and it is now widely used for all heavily loaded gearing where tooth breakage is a problem. The continuous-radius fillet is formed by a cutting tool having

"Time Microscope..."

200 POWER



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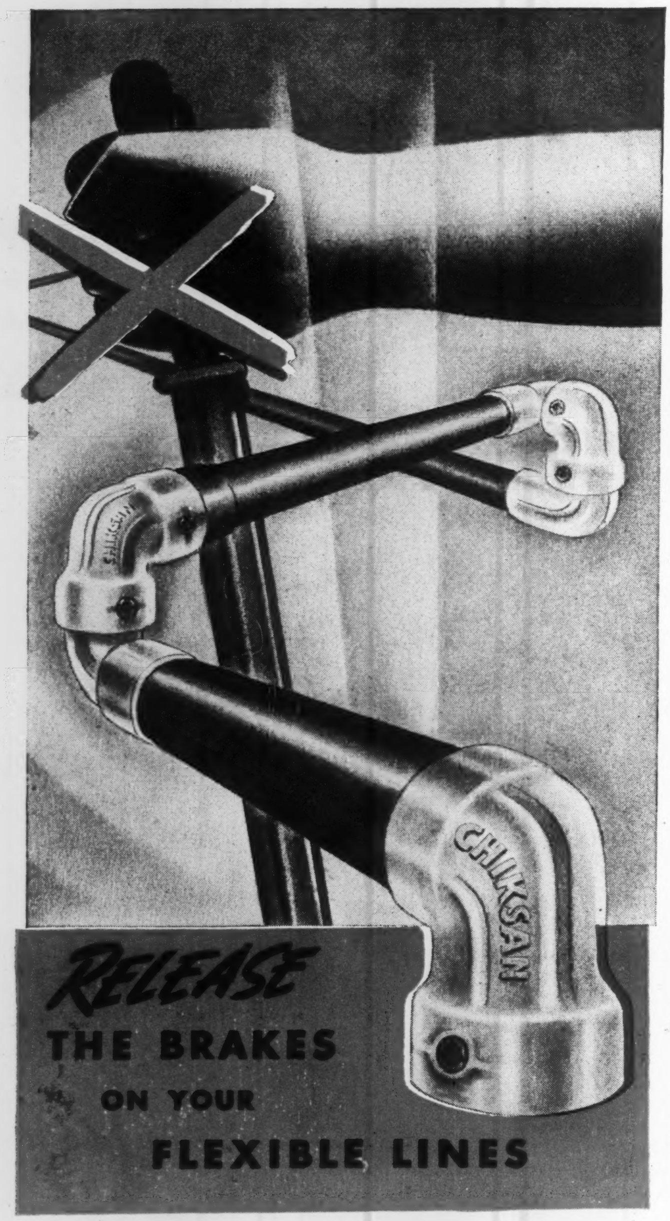

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a round-nosed tip. When the tool is used to cut the particular number of teeth for which it was designed, the fillet radius will be a portion of the arc of a circle, tangent to the tooth profile at a point just below the lowest point of contact. When a different number of teeth is cut, the fillet radius is a compound radius still tangent to the profile. In the case of form-ground teeth the fillet radius may always be an arc of a single radius. The continuous-radius-fillet design reduces the stress-concentration factor in bending to a minimum, because it gives the maximum fillet radius possible for a given design.

Tooth proportions normally used result in a number of teeth in action between 1 and 2. There is usually no attempt to obtain a minimum of two teeth in action. During the first phase of contact on a particular tooth, two teeth work together to carry the load. In the next phase, one tooth carries the load alone, and in the final phase two teeth share the load. The average number of teeth in contact varies from 1.5 to 1.7 for most designs. This number may be permitted to go considerably lower, possibly to 1.35, without disturbing seriously the smoothness of action.

Contact Stress Higher Below Pitch Line

However, the calculation of compressive stress at the pitch line only may not be adequate for such a case, because at the beginning of the period when the total load is carried by one tooth, contact will take place considerably below the pitch line where the radius of curvature of the pinion tooth profile is appreciably less than at the pitch line, with correspondingly higher compressive stress. This is illustrated in *Fig.* 6. A comparison of the 20-degree long and short-addendum design with the 20-degree full-depth design shows that the former has an advantage in this respect.

At any instant the number of teeth in action is an integral number, usually 1 or 2. The average number of teeth in action is found by dividing the length of the line of action by the base pitch, which is the distance between adjacent teeth measured along the line of action and is equal to $(\pi/DP)\ \cos\phi$. Calculation of the number of teeth in action is facilitated by the use of the chart, *Fig.* 7. This chart also shows a method for calculating some other items of interest in design. While this chart is marked for use only when the gears being studied are to be operated on theoretical centers, it may be used for nonstandard centers provided that the operating addenda, pitch radii, and pressure angles are used.

Specific sliding at the tooth tips, defined as the ratio of sliding velocity to pitch-line velocity, also may be calculated from the chart, *Fig.* 7. Rolling contact exists in involute gears only at the pitch point, on either side of which the tooth surfaces slide relatively to each other. For the 20-degree long and short addendum design, maximum sliding occurs at the tip of the pinion tooth.

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G. Niemann—"Walzenfestigkeit und Grubchenbildung von Zahnrad- und Walzlager-Werkstoffen", *Zeit. V.D.I.*, Band 87, 1943, Pages 521, 522, 523.

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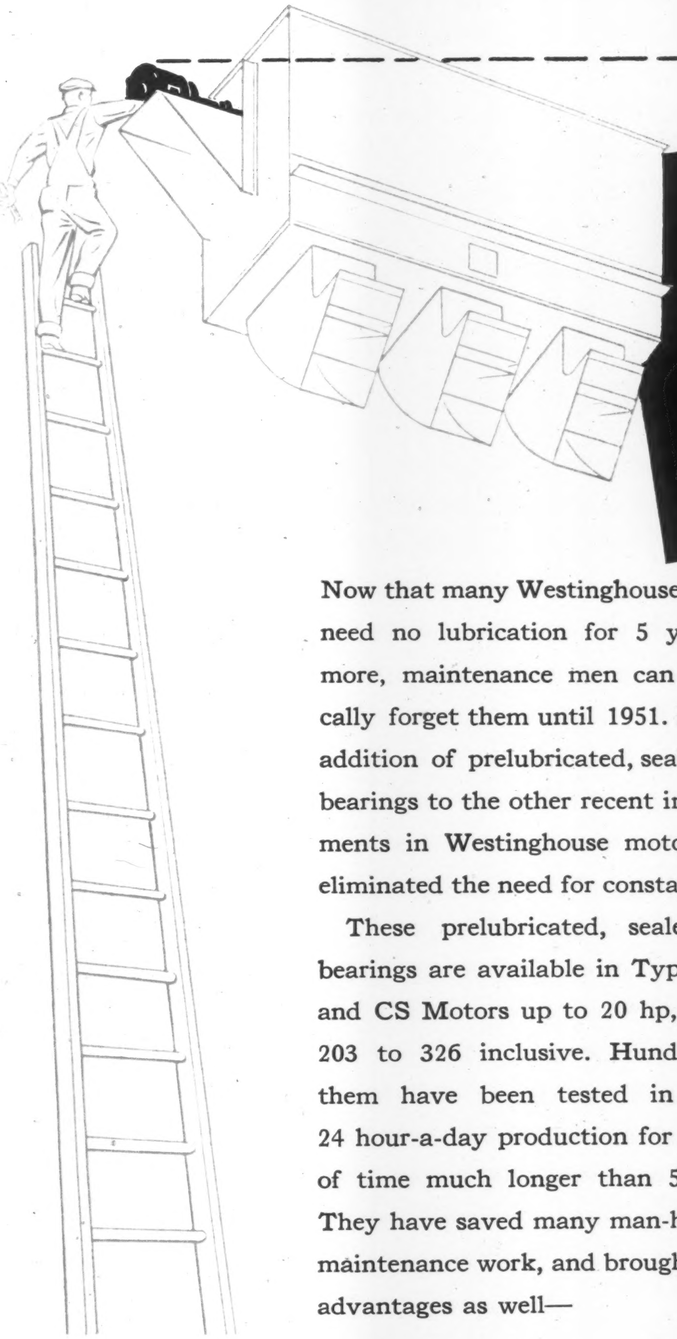

Until 1951, there's no need to have anyone climb a ladder to lubricate this motor.

Now that many Westinghouse motors need no lubrication for 5 years or more, maintenance men can practically forget them until 1951. For the addition of prelubricated, sealed ball bearings to the other recent improvements in Westinghouse motors, has eliminated the need for constant care.

These prelubricated, sealed ball bearings are available in Types CSP and CS Motors up to 20 hp, frames 203 to 326 inclusive. Hundreds of them have been tested in actual 24 hour-a-day production for periods of time much longer than 5 years. They have saved many man-hours of maintenance work, and brought other advantages as well—

- No overgreasing
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- No grease seepage
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This freedom from frequent lubrication brings also a greater freedom to engineers designing new equipment or laying out plants. They can now place motors most advantageously for their operation—unhampered by questions of accessibility and ease of greasing. For further details, write for Bulletin B-3554 and Descriptive Bulletins 3100-CSP and 3100-CS-1, to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

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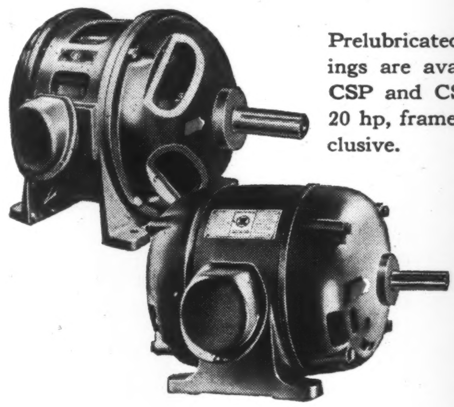
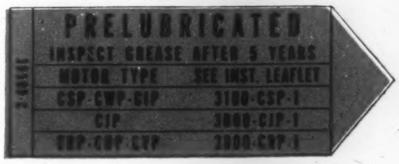
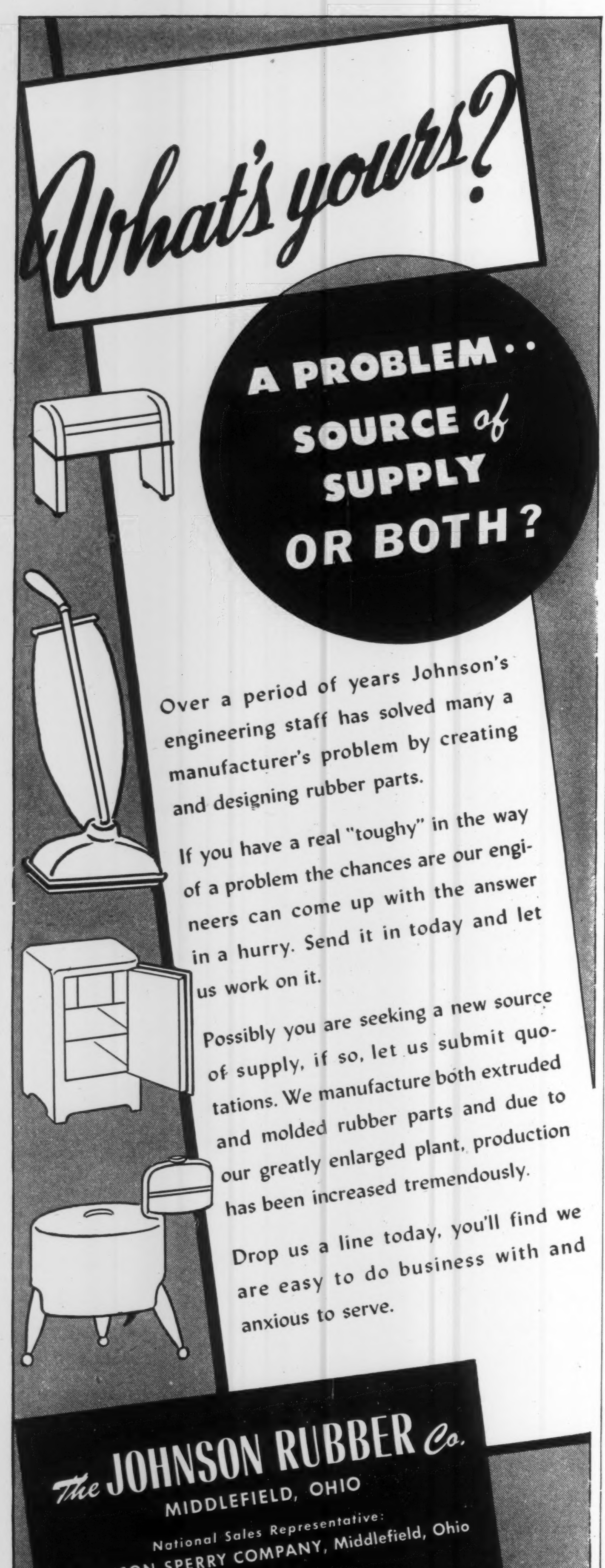


Prelubricated, sealed ball bearings are available in Types CSP and CS Motors up to 20 hp, frames 203 to 326 inclusive.



Another Westinghouse "first" —this label identifies motors that you "don't lubricate for 5 years or more".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BUSINESS AND SALES BRIEFS

ESTABLISHMENT of a branch office in Philadelphia has been announced by Haskelite Mfg. Corp. of Grand Rapids, Mich. Gordon D. Beckwith, sales engineer, has been placed in charge of the new office. Formerly he had been associated with the New York district office.

◆

With headquarters at the New York office, 96 Lafayette St., Eric N. Svensk has been made sales representative for the Corbin Cabinet Lock Division of The American Hardware Corp. He will cover territory including New York City and part of New Jersey.

◆

A new plastics concern known as Milwaukee Plastics Inc. has been formed at 31st & Capitol Drive, Milwaukee 9. The new company will engage in both compression and injection molding.

◆

Grayhill of Chicago, manufacturer of industrial electrical switches, has added facilities to mold small phenolic pieces on a low-production basis. The company specializes in single and two-cavity molds at a low cost for experimental processes.

◆

Following the recent resignation of Carl Claus, Richard Wellbrock has been named sales manager of New Jersey Machine Corp., Hoboken, N. J. Mr. Wellbrock has been connected with the company for nine years as sales engineer.

◆

In addition to his position as manager of the Los Angeles office, Harvey A. Craig has been appointed Pacific Coast manager of Republic Steel Corp. He will supervise the territory served by his office and the other two Coast sales offices of the company. W. L. Thoma will continue to be district sales manager of the San Francisco office, while C. V. Gardner will remain in charge as district sales manager of the Seattle office.

◆

According to an announcement by Electro Metallurgical Sales Corp., Thomas C. Ford has been named district manager of the Pittsburgh office.

◆

Sales engineer in the Newark, N. J., office of Westinghouse Electric Corp. for the last nine years, James Adair has joined the sales engineering staff of Star Electric Motor Co. of Providence, R. I., and will cover the New Jersey industrial area.

◆

Appointment of the following sales agents to handle its products has been announced by The Reliable Spring & Wire Forms Co., Cleveland: W. E. Fry & Co., 909 Wyandotte, Kansas City 6, Mo., to cover the Kansas and Nebraska territory; R. P. Vallee, 719 East Knapp St., Milwaukee 2, to handle the Milwaukee and Fox River Valley territory; L. N. Finch, 55 Erie

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Stainless Steels have remarkable resistance to a wide variety of corrosion conditions and to the effects of high temperature exposure; no plating to peel or wear off; no paint to chip; possess resistance to abrasion and erosion and eliminate contamination.

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Over a wide temperature range Stainless Steels, depending upon grade and size, offer: tensile strengths ranging from 70,000 to 300,000 pounds per square inch; high yield strengths; high strength-weight ratios, thus permitting lighter, safer, and more dependable structures.

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Stainless Steels will absorb great shock loads even at extremely low temperatures and have exceptional endurance strength; yet they can be machined, formed and welded with ease.

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Because the characteristics of Stainless Steels differ from one another and from other materials, you will want to consult Rustless—America's specialists in Stainless Steels—for data and experience necessary for proper design and selection.

All Stainless Steels contain as a basic ingredient ten percent or more chromium. It is this element which produces the corrosion and scale resisting properties. Such elements as nickel, molybdenum, columbium, titanium and several others contribute special attributes.

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Rustless 12	Type 410	A wide range of physical properties may be obtained by quenching from hardening heat. The high carbon grades are generally used in the hardened and stress-relieved condition.
Rustless 12T	Type 403	
Rustless 12FM	Type 416	
Rustless 13-C-35	Type 420	
Rustless 13-C-35FM	Type 420F	
Rustless 16-2	Type 431	
Rustless 17-C-60	Type 440A	
Rustless 17-C-80	Type 440B	
Rustless 17-C-100	Type 400C	
Rustless 17-C-100FM	Type 440FM	
Straight Chromium—Non-Hardenable		
Rustless 17	Type 430	Superior in corrosion resistance to above group. Generally used in annealed or soft condition.
Rustless 17FM	Type 430F	
Rustless 21	Type 442	
Rustless 27	Type 446	
Chromium-Nickel—Hardenable by Cold Work Only		
Rustless 18-8	Type 302	Highest corrosion resistance of all. Non-magnetic when annealed, becoming magnetic as cold worked. Exhibit extraordinary resistance to stress concentration.
Rustless 18-8	Type 304	
Rustless 18-8FM	Type 303	
Rustless 25-12	Type 309	
Rustless 18-12-3Mo.	Type 316	
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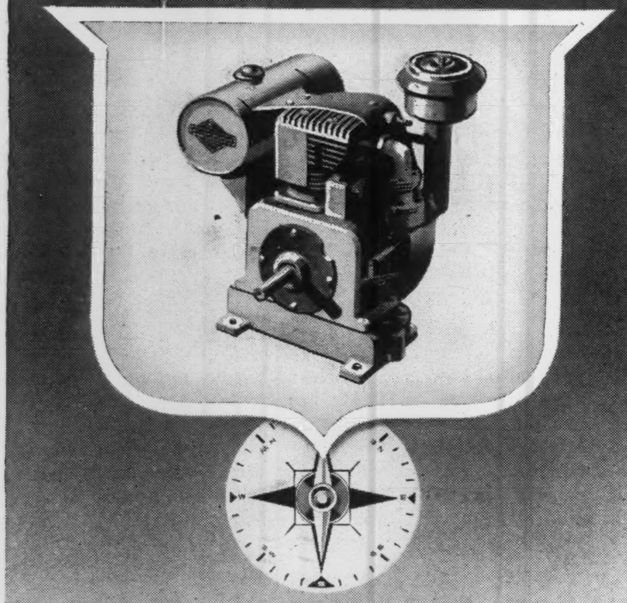

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Lane, New Hyde Park, Long Island, N. Y., to cover the metropolitan New York territory; H. P. Fillmore, Liberty Bank Bldg., Buffalo, N. Y., to handle the western New York territory; C. W. Weston, 1124 Burgundy St., New Orleans 16, La., to cover the southern Mississippi territory; and J. A. Campbell, 4226 Cedar Springs, Dallas 4, Tex., to handle the Texas territory.

◆

Transferred from the New England district, William H. Stenger has succeeded Lloyd R. Clowes as Pittsburgh district manager of Firth-Sterling Steel Co. Mr. Clowes has been appointed assistant general sales manager of the company.

◆

Osborn Mfg. Co. of Cleveland has named Robert Wier Jr. as general sales manager of the brush division. Formerly Mr. Wier had been sales manager of the Western Cartridge Co., with headquarters at the Winchester Repeating Arms Co.

◆

Previously located at 440 West Huron street, the Chicago office of Bentley, Harris Mfg. Co. of Conshohocken, Pa., has been moved to 43 East Ohio street. Frank W. Garner has been placed in charge of the Boston office at the Rice building, 10 High street.

◆

Appointment of the following has been announced by The McIntyre Co. of Newton, Mass., manufacturer of precision pumps and hydraulic motors: R. Louis Towne, as director of sales; S. M. Treman, as sales engineer; and R. F. Kemper, as advertising and sales promotion manager.

◆

From American Car & Foundry Co., Consolidated Vultee Aircraft Corp. has purchased the controlling interest in ACF-Brill Motors Co. and its wholly-owned subsidiary, Hall-Scott Motor Car Co. of California.

◆

New engineering and sales offices have been opened by C. P. Clare & Co. at 420 Lexington Ave., New York, and in the Commercial Trust Bldg., Philadelphia. J. W. Concagh and Frazier O. Stratton have been placed in charge of the New York and Philadelphia offices, respectively. Harold M. West will be associated with Mr. Concagh at New York as field engineer.

◆

With headquarters at 320 Ontario St., Toledo 2, William H. Marion has been appointed to serve as representative in northern Ohio for Progressive Welder Co., Detroit. Prior to his service with the Procurement Division of the Army Transport Command, Mr. Marion had been connected with Taylor-Winfield Corp.

◆

Election of Don G. Mitchell as executive vice president has been announced by Sylvania Electric Products Inc. Mr. Mitchell joined the company in 1942 as vice president in charge of sales.

◆

Brown Instrument Co. has assigned twenty-four sales engineers to branch offices of Minneapolis-Honeywell Regulator Co., of which the Brown company is the industrial division. They are: D. L. Russell, assigned to Boston; A. F. Cecere, to Hartford, Conn.; J. A. Rorex, to Houston, Tex.; R. Mitchell, A. D. Mayo Jr. and H. W. Greisback, Chicago; C. C. Spousta Jr. and A. R. Willy, Indianapolis; D. F. DeVine, Portland, Ore.; W. H.

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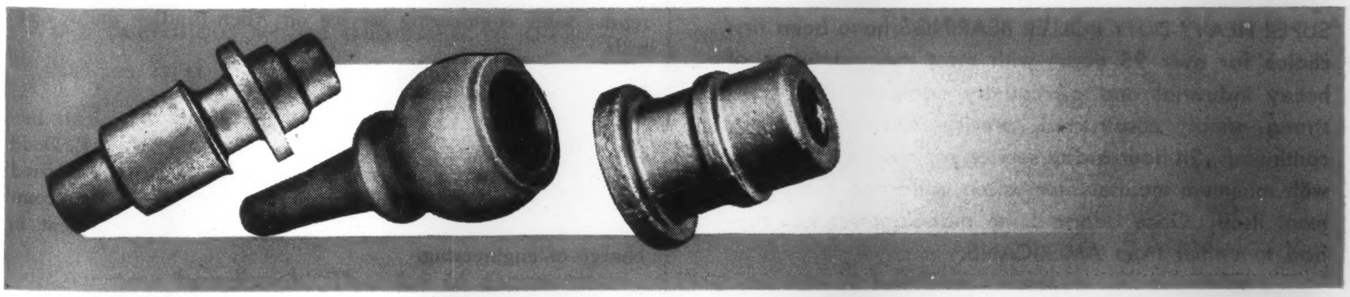

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TUBE TURNS' forging set-up is entirely self-sufficient. Modern, extensive facilities for every operation pertaining to the mass-production of better forgings are maintained under one roof. There is no division of responsibility. You get a highly desirable continuity of effort from the start to the finish of any forging job.

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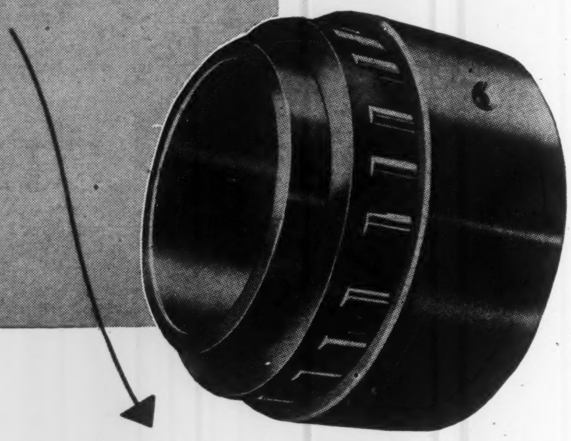

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1718 S. Flower St., Los Angeles, California

AMERICAN
Heavy-Duty ROLLER BEARINGS

Palmer and Ross Hubley, Minneapolis; J. Dunlap, Toledo; H. W. Araucz, Detroit; A. T. Challman, San Francisco; H. T. Noonan, Buffalo, N. Y.; L. T. Macgill and A. M. Zellar, Philadelphia; C. McIntire, Cincinnati, O.; R. D. Bailey, Washington, D. C.; J. F. Stein, St. Louis; H. W. Sinewe, Pittsburgh; R. A. Wolfe and E. G. Brown, New York City; and R. F. Bruckart, Cleveland.

◆

Announced by Sterling Alloys Inc. is the appointment of Stanley G. Disque, 620 Board of Trade building, Indianapolis, as engineering service representative for the company in the state of Indiana.

◆

Having served as a sales engineer for the company prior to the war, Harold A. Chamberlin has been made field engineer in the New England territory of the Manufacturing Division of Alliance Mfg. Co., Alliance, O. With headquarters at 31 Milk St., Boston, Mr. Chamberlin will cover Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.

◆

Wilson H. Moriarty has been elected vice president in charge of sales of National Malleable & Steel Castings Co. He has been assistant to the president.

◆

Opening of a Cincinnati Technical Section of its Development and Research Division has been announced by the International Nickel Co. Inc. Located at 1715 Carew Tower, Cincinnati 2, the new section will furnish technical assistance to industry in the territory covering southwestern Ohio, the southern half of Indiana, and Kentucky. Richard B. Kropf, metallurgist, has been placed in charge. Formerly Mr. Kropf had been district manager at Hartford, Conn., for Copperweld Steel Co.

◆

To serve as its new representative in the Seattle area, Allen-Bradley Co. of Milwaukee has appointed Muth-Richards Co., 1426 Broadway, Seattle 22, Wash. Headed by Lawrence Muth and Willis C. Richards, the newly organized company will render sales engineering service on Allen-Bradley motor controls.

◆

Recently made known by Durez Plastics & Chemicals Inc. of North Tonawanda, N. Y. are the elections of Robert E. Dodd as vice president in charge of industrial resin sales, Alfred W. Hanmer Jr. is vice president in charge of molding compound sales, and Robert M. Crawford as vice president in charge of engineering.

◆

Appointment of L. A. Kristoff as head of the new Permanent Mold Castings Division has been announced by The John Harsch Bronze & Foundry Co.

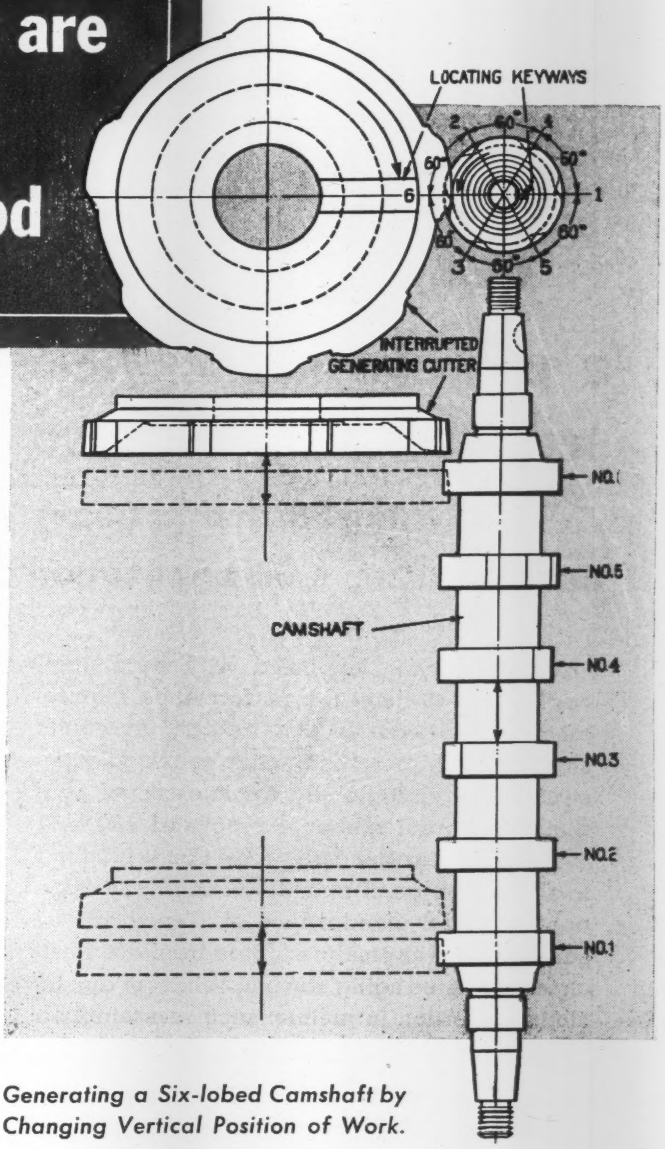
◆

With offices at 538 Terminal Tower Bldg., Cleveland, David C. Williams has been made Tenite sales representative for Tennessee Eastman Corp. The area he will serve was formerly covered partly out of Detroit and partly out of Buffalo.

◆

United States Rubber Co. has appointed John S. Lawrence as district sales manager of the Denver branch of the mechanical goods division. Mr. Lawrence will cover the territory of Wyoming, Colorado, New Mexico, southwestern Montana, and

Many Non-Gear Parts are made More PRECISE by The Fellows Method



Generating a Six-lobed Camshaft by Changing Vertical Position of Work.

Take a close look at this 6-Lobed Cam-shaft. It is a typical example of many non-gear parts that can be *generated* to higher accuracy *in a single work setting* on the versatile Gear Shaper.

To machine this part, the Gear Shaper is equipped with a special work-holding fixture and auxiliary work-elevating mechanism. The fixture is provided with a keyway for correct positioning of the work, and to assure accurate location of the cams. The cutter, which is a "conjugate" to the shapes of the various cams, is made with cutting "lobes" spaced to agree with the location of the cams on the shaft.

The Gear Shaper possesses production advantages especially applicable to difficult machining operations where alignment of different shapes is a necessary requirement. Supplementing the Gear Shaper is the Gear Shaper Cutter which can be made to produce difficult and complicated parts to a high degree of accuracy.

Our new handbook, "The Art of Generating With a Reciprocating Tool", illustrates many interesting facts concerning parts of this type. Fellows Sales Engineers will gladly assist in applying them to your specific problem. Write: The Fellows Gear Shaper Company, Springfield, Vt., or 616 Fisher Bldg., Detroit, or 640 West Town Office Bldg., Chicago.

Fellows

THE FELLOWS METHOD...MACHINES AND TOOLS FOR ALL OPERATIONS FROM BLANK TO FINISHED GEAR

Now Available . . .
after vigorous war testing

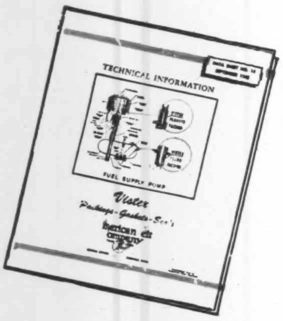
VISTEX

a positive sealing and self-lubricating element

. . . for packing washer or heavy duty bearing seal application

Vistex is a sheet laminated, felt base material engineered to meet the performance requirements of automotive and military hydraulic shock and shimmy dampener packings. Constructed of multiple ply thicknesses of synthetic or natural rubber impregnated felt, and available in four standard types, Vistex is suited to a broad range of operating conditions. High operating and maintenance efficiency are assured without premature failure from overheating, accelerated aging, decomposition or dimensional distortion in maintenance reassembly.

Please write, on your letterhead, for samples and Data Sheet No. 14, "Vistex Packings—Gaskets—Seals"



Send for

Data Sheet No. 14.

American Felt Company
TRADE MARK

General Offices: GLENVILLE, CONN.

New York; Boston; Chicago; Detroit; Philadelphia; Cleveland; Dallas; St. Louis; Atlanta; Los Angeles; San Francisco; Seattle; Portland.

the city of El Paso, Tex. Previously this territory had been under the tentative supervision of J. W. Batten, who will now devote all his time to his position as district sales manager of the Kansas City, Mo., and Tulsa branches.

◆

Opening of new engineering laboratories at Rockford, Ill., has been announced by the Rockford Clutch Division of Borg-Warner Corp.

◆

Previously located at English & Neave Sts., Cincinnati, Precision Welder & Machine Co. has moved to its newly purchased building at 138 East McMicken Ave.

◆

Appointment of the following sales representatives has been announced by Sterling Alloys Inc., Woburn, Mass.: J. P. Clark Co., 1420 Chestnut St., Philadelphia, to cover the eastern Pennsylvania, southern New Jersey, Delaware, Md., and Virginia territory; B. G. Constantine, 51 Converse St., Springfield, Mass., to handle the western Massachusetts, Vermont, northeastern New York, and Connecticut territory; Walz & Krenzer Inc., 250-252 Mt. Hope Ave., Rochester, N. Y., to cover the central and western New York State territory; and W. F. Berryman, to handle the eastern Massachusetts, Rhode Island, New Hampshire and Maine territory.

◆

Celanese Corp. of America has acquired a new plant at Belvidere, N. J., for the production of chemicals, plastics, and related products. Celanese Plastics Corp., wholly-owned subsidiary, will sell the products manufactured at the plant.

◆

Election of W. J. Priestley as vice president in charge of the Alloys & Metals Division has been made by Union Carbide & Carbon Corp., New York.

◆

Previously sales promotion manager of the company's paper plant at Van Wert, O., John A. Benjamin has been named acting general manager of the Plastics Division of Continental Can Co., Cambridge, O. He has replaced J. E. Wolfe, who resigned recently.

◆

On leave with the armed forces for three and a half years, F. D. Crowther has resumed his position as sales manager of the Lighting Division of General Electric Co.

◆

Appointment of James E. Sweeney as vice president and general sales manger has been announced by Kropp Forge Co., Chicago. Mr. Sweeney previously served as works manager.

◆

Following the resignation of John Avery, Melvin C. Shaw has been made manager of the blower and compressor department of Allis-Chalmers Mfg. Co., Milwaukee. Also announced by the company is the appointment of A. W. Kremser as sales manager of the Davenport, Ia., office, to succeed C. J. Shutty who has been transferred to the Kansas City office. Mr. Kremser formerly had been field engineer in the Chicago office.

◆

B. F. Goodrich Co., which recently celebrated its seventy-fifth anniversary, is constructing a new and complete research center on a 260-acre tract near Brecksville, O.

Solving SOME MIGHTY BIG PROBLEMS!
TRIPLE-ALLOY STEELS
CONTAINING
NICKEL

● The widespread use of triple-alloy steels containing Nickel, chromium and molybdenum is based on extensive experience in widely divergent engineering fields.

It has been found that they can be counted on for consistent performance. The depth to which full hardness is developed is comparable to that attained by other alloy steels. Their response to heat treatment is dependably uniform.

Moreover, the wide range of compositions available, makes it possible to select *accurately* suitable alloy steels for a broad range of applications.

Inquiries regarding the selection and uses of triple-alloy steels containing Nickel are invited.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street
New York 5, N. Y.

OHIO *Small* **MOTORS**

VERSATILE and EFFICIENT

● For general purpose applications. Split capacitor type..1400 to 3400 RPM ..1/80 to 1/20 HP..Voltages up to 220 AC..60, 50 and 25 cycles..bases solid, resilient or flange for horizontal, sidewall, ceiling or vertical mountings, shaft up or down.

What is Your Problem?

THE OHIO ELECTRIC MFG. CO.
5906 Maurice Avenue, Cleveland, Ohio

OHIO TORQUE MOTORS

● Will rotate slowly or stand stalled exerting full torque without overheating for any time cycle. Ball bearing and quiet operating. Built for multiple or single phase a.c., and for direct current. Sizes to exert torque from 1 oz. ft. to 100 oz. ft. equal to 1/16 ft. lb. to 6¼ ft. lb.

WHAT IS YOUR PROBLEM?

THE OHIO ELECTRIC MFG. CO.
5906 Maurice Avenue, Cleveland, Ohio

OHIO *Shell-type* **MOTORS**

COMPACT and EFFICIENT

● Stator is pressed into a heavy steel shell and rotor is bored to be mounted on spindle. Stator and rotor are machined to very close limits. Ratings from ¼ to 5 HP—1150, 1750 and 3500 RPM., 110, 220, 440 & 550V. polyphase.

THE OHIO ELECTRIC MFG. CO.
5906 Maurice Avenue, Cleveland, Ohio

OHIO INTEGRAL MOTORS

● Fully enclosed. Rotor dynamically balanced. Runs quietly with minimum vibration. 2 or 3 phase, 60 or 50 cycles; voltages, 110, 220, 440 and 550; sizes ½ to 2 HP. Speeds from 860 to 3500 RPM. Odd voltages and cycles also available.

WHAT IS YOUR PROBLEM?

THE OHIO ELECTRIC MFG. CO.
5906 Maurice Avenue, Cleveland, Ohio

OHIO AIRCRAFT MOTORS

● Can be supplied as follows: Speeds up to 7500 RPM. Voltages 12 or 24 volts, DC. HP range 1/100 to ⅓ HP. Weight and length vary with HP and speed. Mounting and shaft to specifications.

Furnished with or without magnetic brake and with or without cooling fan.

THE OHIO ELECTRIC MFG. CO.
5906 Maurice Avenue, Cleveland, Ohio

Meetings and Expositions

March 18-21—
National Warm Air Heating & Air Conditioning Association. Fifteenth annual four-day forced warm air conference to be held at Michigan State College, East Lansing, Mich. Geo. Boeddener, 145 Public Square, Cleveland, is managing director.

April 1-3—
American Society of Mechanical Engineers. Spring meeting to be held at Chattanooga, Tenn. Additional information may be obtained from headquarters of the society at 29 West 39th St., New York. C. E. Davies is secretary.

April 3-5—
Society of Automotive Engineers Inc. National aeronautic meeting (Spring) to be held at Hotel New Yorker, New York. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

April 8-12—
American Society of Tool Engineers. Fifth exposition to be held at Cleveland Auditorium, Cleveland. Additional information may be obtained from headquarters of the society at 1666 Penobscot Bldg., Detroit 26.

April 10-13—
Electrochemical Society Inc. Spring congress to be held at Hotel Tutwiler, Birmingham, Ala. Colin G. Fink, 3000 Broadway, New York 27, is secretary.

April 15-18—
National Warm Air Heating & Air Conditioning Association. First annual warm air heating conference to be held at the College of Applied Science of Syracuse University, Syracuse, N. Y. Geo. Boeddener, 145 Public Square, Cleveland, is managing director.

April 22-27—
Society of the Plastics Industry Inc. First national plastics exposition to be held at Grand Central Palace, New York 17. W. T. Cruse, 295 Madison Ave., New York 17, is executive vice president.

April 28-May 1—
American Ceramic Society Inc. Forty-eighth annual meeting to be held at Hotel Statler, Buffalo. Ross C. Purdy, 2525 North High St., Columbus 2, O., is general secretary.

May 6-10—
American Foundrymen's Association. Foundry congress and show to be held at Cleveland Auditorium, Cleveland. Wm. W. Maloney, 222 West Adams St., Chicago 6, is secretary.

June 3-5—
American Gear Manufacturers Association. Thirtieth annual meeting to be held at The Homestead, Hot Springs, Va. Newbold C. Goin, Empire Bldg., Pittsburgh 22, is executive secretary.

June 3-6—
American Society of Mechanical Engineers. Aviation Division meeting to be held at Los Angeles. Additional information may be obtained from headquarters of the society at 29 West 39th St., New York. C. E. Davies is secretary.

June 12-15—
American Society of Mechanical Engineers. Oil and Gas Power Division meeting at Milwaukee. Additional information may be obtained from C. E. Davies, secretary of the society, at the headquarters at 29 West 39th St., New York.

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